Atlanta NAVIGATOR Case Study

PUBLICATION NO. FHWA-RD-98-099

NOVEMBER 1998

U.S. Department of Transportation
Federal Highway Administration

Research and Development
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

FOREWARD

This is one of two reports documenting the Atlanta, Georgia experience in deploying Intelligent Transportation Systems (ITS) during the Atlanta Centennial Olympic Games and subsequent Paralympic Games in the Summer of 1996. This report, the NAVIGATOR Case Study, focuses on the issues faced by local officials in planning and deploying an extensive and ambitious ITS system in the Atlanta area. The lessons learned and recommendations contained in this report will be of value for local officials considering deployment of ITS in a metropolitan area.

A. George Ostensen
Director, Office of Safety
and Traffic Operations
Research and Development

Technical Report Documentation Page

1. Report No. FHWA-RD-98-099	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle ATLANTA NAVIGATOR CASE STUDY		5. Report Date November 1998
		6. Performing Organization Code Booz•Allen & Hamilton Inc.
7. Author(s) Richard Amodei, Erin Bard, Bruce Brong, Frank Cahoon, Keith Jasper, Keith Manchester, Nancy Robey, Don Schneck, Brian Stearman, Sam Subramaniam		8. Performing Organization Report No.
9. Performing Organization Name and Address Booz•Allen & Hamilton Inc. 8201 Greensboro Drive Suite 609 McLean, Virginia 22102		10. Work Unit No. (TRAIS) B1e
		11. Contract or Grant No. DTFH61-94-C-00207
12. Sponsoring Agency Name and Address Office of Safety and Traffic Operations Research and Development Federal Highway Administration 6300 Georgetown Pike McLean, Virginia 22101-2296		13. Type of Report and Period Covered Final Report May 1996 - June 1997
		14. Sponsoring Agency Code

15. Supplementary Notes

Contracting Officer's Technical Representative (COTR) - Michael Freitas, HSR-10

16. Abstract

The Atlanta metropolitian region was the location of one of the most ambitious Intelligent Transportation Systems (ITS) deployments in the United States. This deployment included several individual projects—a Central Transportation Management Center (TMC), six Traffic Control Centers (TCC), one Transit Information Center (TIC), the Travel Information Showcase (TIS), and the extension of the Metropolitan Atlanta Rapid Transit Authority (MARTA) rail network and the new high-occupancy vehicle (HOV) lanes on I-85 and I-75.

The Atlanta Centennial Olympic Games and Paralympic Games created a focus for these projects. All of these systems were to be brought on line in time for the Olympic Games.

This report presents the findings of the NAVIGATOR Case Study and documents the lessons learned from the Atlanta ITS deployment experience in order to improve other ITS deployments in the future. The Case Study focuses on the institutional, programmatic, and technical issues and opportunities from planning and implementing the ITS deployment in Atlanta.

The Case Study collected data and information from interviews, observations, focus groups, and documentation reviews. It presents a series of lessons learned and recommendations for enabling successful ITS deployments nationwide.

17. Key Words ITS, Atlanta, NAVIGATOR, ITS Case Study, ITS Lessons Learned, ITS Deployment		18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 163	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3

NOTE: Volumes greater than 1000 l shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

SECTION **PAGE**

TABLE OF CONTENTS (Continued)

SECTION **PAGE**

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AAA	American Automobile Association
ACOG	Atlanta Committee for the Olympic Games
ADAS	Atlanta Driver Advisory System
APC	Automated Passenger Count
APD	Atlanta Police Department
APTS	Advanced Public Transportation Systems
ARC	Atlanta Regional Commission
ATC	Automatic Train Control
ATIS	Advanced Traveler Information System
ATMS	Advanced Transportation Management System
ATOC	Atlanta (APD) Traffic Operations Center
AVL	Automatic Vehicle Location
BA&H	Booz·Allen & Hamilton Inc.
BBS	Bulletin Board System
CAAA	Clean Air Act Amendments of 1990
CBD	Central Business District
CCB	Configuration Control Board
CCT	Cobb Community Transit
CCTV	Closed Circuit Television
CM	Configuration Management
CMAQ	Congestian Management and Air Quality
CMS	Changeable Message Sign
DOD	Department of Defense
DOT	Department of Transportation
EFIT	Engineer, Furnish, Install and Test
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
FOT	Field Operational Test

LIST OF ACRONYMS (Continued)

GDOT	Georgia Department of Transportation
GEMA	Georgia Emergency Management Administration
GIS	Geographic Information System
GPS	Global Positioning System
GSP	Georgia State Patrol
HAR	Highway Advisory Radio
HERO	Highway Emergency Response Operators
HOV	High Occupancy Vehicle
IMS	Incident Management System
IOC	International Olympic Committee
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITS	Intelligent Transportation Systems
IVA	In-Vehicle Announcements
IVHS	Intelligent Vehicle Highway Systems
LAT	Local Area Transceivers
LED	Light Emitting Diode
MARTA	Metropolitan Atlanta Rapid Transit Authority
MPO	Metropolitan Planning Organization
NEMA	National Electrical Manufacturers Association
NHS	National Highway System
O&M	Operations and Maintenance
OSTS	Olympic Spectator Transportation System
OTS	Olympic Transportation System
OTSG	Olympic Transportation Support Group
PARIS	Passenger Routing and Information System (a.k.a. Itinerary Planning)
PCD	Passenger Counting Devices
PID	Passenger Information Device
PTS	Paralympic Transportation System
PS&E	Plans, Specifications, and Estimates

LIST OF ACRONYMS (Continued)

STIC	Subcarrier Traffic Information Channel
TATS	Traveler Advisory Telephone System
TCC	Traffic Control Center (sometimes Transportation Command Center as in APOC)
TDM	Travel Demand Management
TIC	Transit Information Center
TIP	Transportation Improvement Program
TIS	(Atlanta) Traveler Information Showcase
TMC	Transportation Management Center
VIDS	Video Image/Detection System
VIP	Video Image Processing

EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The Atlanta metropolitan region is the location of one of the most ambitious Intelligent Transportation Systems (ITS) deployments in the United States. The system includes a Transportation Management Center (TMC), six Traffic Control Centers (TCC), and a Transit Information Center (TIC) linking eight regional agencies. In addition, regional Advanced Transportation Management Systems (ATMS) including incident management, regional Advanced Traveler Information System (ATIS), and Advanced Public Transportation Systems (APTS) were implemented. The 1996 Summer Olympic and Paralympic Games, held in Atlanta, created a focus for these projects. The goal was to bring all of these new systems on line in time for the games. Collectively, this program is referred to as NAVIGATOR. The games also served as a focus for an extension of the area's High Occupancy Vehicle (HOV) lanes, and of the Metropolitan Atlanta Rapid Transit Authority (MARTA) rail network.

ES.1.1 The Atlanta ATMS Partners

Eight agencies were involved in the deployment of the integrated, multimodal ATMS. They are the Georgia Department of Transportation (GDOT), the City of Atlanta, MARTA, and the Counties of Clayton, Cobb, DeKalb, Fulton, and Gwinnett. These agencies are referred to as the ATMS partners. Although not designated as partner agencies, the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), and the Atlanta Regional Commission (ARC) were also involved in the ITS deployments, and provided overall project support.

ES.1.2 Purpose of the Case Study

What distinguished the NAVIGATOR deployment from others in the United States was the regional, multimodal scope of the deployment and the firm operational deadline imposed by the 1996 Summer Olympic and Paralympic Summer Games. The NAVIGATOR Case Study focuses on the institutional, programmatic, and technical issues and opportunities in planning and implementing the ITS deployment. The purpose of the Case Study is to document those issues and opportunities on the basis of interviews, observations, focus groups, and documentation reviews, and to present recommendations to be considered at Federal, State, regional, and local levels for future ITS deployments. The Case Study responds to the question: *"What can be learned from the Atlanta experience to improve other ITS deployments in the future?"*

ES.1.3 The Case Study and the Event Study

In addition to the Case Study, Booz·Allen and Hamilton was commissioned in May 1996 by the FHWA to undertake the Olympics Event Study. The Event Study was an independent, high-level review of the performance of various ITS deployments and new infrastructure extensions during the Olympic and Paralympic events period. The objective of the Event Study was to determine the technical, operational, and institutional lessons learned during the 1996 Olympic and Paralympic Games. The Event Study has been completed and published as a separate report.

ES.1.4 Case Study Approach

The Case Study discusses the similarities and differences between traditional transportation projects and ITS projects. The challenges of deploying complex ITS programs require agencies to modify their standard approach to projects and expand their capabilities. The Atlanta experiences are described in the context of the agencies' ability to adapt existing or adopt new "ways of doing business." The main findings of this study were presented and discussed in a focus group environment involving all key stakeholders of NAVIGATOR. At the completion of all study activities, 45 summary points (or lessons learned) were identified. These are presented and cross-referenced to the main findings in Table ES-1 through Table ES-4 later in this Executive Summary as well as in the detailed Case Study document.

Recommendations that can help guide future ITS deployments were developed on the basis of the main findings and lessons learned. The recommendations are at a high level, and focus on some of the basic needs to structure ITS programs for success. They address the fundamental differences between traditional transportation and ITS programs. The recommendations should not be considered as a comprehensive work plan for ITS deployments. Rather, they indicate major milestones and tasks that should be tailored to each location's needs.

ES.1.5 Target Audience

The recommendations presented in this report are targeted at Federal, State, and local agencies. At the Federal level, the recommendations suggest guidance and support to be provided to local agencies. The local level recommendations can be implemented directly by State and local transportation agencies.

ES.2 FINDINGS

The ATMS partners recognized early that, to successfully implement ITS, they needed to adopt modified processes and additional resources specific to ITS and provide new types of support. For traditional transportation projects, extensive support is provided by local agencies in the Atlanta region, as well as by FHWA and

FTA. Design manuals, procurement manuals, training courses, workshops, and publications are continually updated. Similar resources exist only on a limited scale for ITS.

The ATMS partners also recognized that they needed to enhance their skills in order to support ITS deployment. They needed to learn how to approach systems engineering projects and how to manage them. The skills needed to operate and maintain ITS deployments are also different from those typically found in traditional transportation agencies. In addition, the ATMS partners understood that ITS system performance can be maximized when agencies work together. To accomplish this, the partner agencies agreed that their own interagency coordination skills should be improved.

Thus, the study presents five major groups of findings. They relate to the need to develop guidance for ITS "recommended approaches" and "measures of effectiveness," and the need to improve ITS-related skills. These findings are:

1. **Improve Program/Project Management Skills:** Improve agency staff skills related to overall program and project management, including programming funds for large regional projects; managing projects with uncertain outcomes; managing projects involving multiple agencies; managing system implementation projects; and working with consultants who are truly "outside experts" and bring skills not available among existing staff.
2. **Improve Interagency Coordination Skills:** Improve agency staff skills related to agreeing on shared goals and assisting with decision consensus among a variety of interest groups, and maintaining open and unbiased communications.
3. **Improve ITS Technical Skills:** Improve agency staff understanding of the detailed technical workings of ITS projects including software development, hardware design, system integration, communications technologies, and other electronics.
4. **Develop Guidance for ITS "Recommended Approaches:"** Guidance should be developed related to how ITS programs should be conducted, i.e., what should be included in program management, and what documents and deliverables are needed.
5. **Develop ITS Measures of Effectiveness:** Guidance should be developed to provide a basis for comparison or measurement to determine completeness and appropriateness of project deliverables, to measure progress, and to determine how well the system meets the requirements.

As found in the interviews and documentation and reiterated in the focus group discussions, transportation agencies are currently performing ITS projects without the benefit of guidance on how such projects should be conducted and how to determine if the outcomes meet the requirements. While traditional transportation projects are guided by multiple manuals and other guidelines, ITS projects are not.

However, because ITS is still maturing, the ATMS partner agencies, FHWA, and FTA strongly advised that overall guidance, rather than strict guidelines full of requirements, be developed that can respond to the evolving nature of the work.

As discussed earlier, 45 summary points (or lessons learned) were identified by study participants. Tables ES-1 through ES-4 present these summary points and relate them to the five main findings of the study. Each table contains the five major groups of findings discussed previously. Each of the 45 summary points, along with the significant skills required to address the issue or need raised by that summary point, are presented. Guidance in the form of recommendations of suitable approaches and measures of effectiveness that will assist in addressing the issue or need raised by the summary point is also presented in these tables.

Each table relates to a different phase of traditional transportation program development:

- **Initial Planning Phase.** This phase traditionally covers early planning. In the ITS context this includes concept definition, needs identification, and commencement of interagency discussions to finalize the deployment concept.
- **Design Phase.** This phase traditionally involves the design of the infrastructure. In the ITS context this includes detailed functional requirements development, specifications, technology reviews and selection, and integration plans.
- **Consultant Services Procurement Phase.** Typically consultants are employed to finalize the designs and plans for most projects. This is particularly true for ITS deployments which have complex technology requirements and unique needs. This phase covers the procurement of the consultant services.
- **Construction Phase.** This phase refers to the actual construction of the facility in traditional projects. In ITS deployments this phase deals with a variety of aspects, from actual building construction (e.g., TMC buildings) to communications backbone deployment (e.g., fiber-optic cable deployment) to total system integration before handover to the DOT.

ES.2.1 Initial Planning Phase

Table ES-1 presents the lessons learned from the Atlanta experience during the initial planning phase. Interagency coordination and recommendations of approaches to achieve success are the major needs of this phase.

TABLE ES-1
Lessons Learned—Initial Planning Phase

Ref. No.	Summary Point	ITS Skill Areas			Guidance	
		Program Management	Interagency Coordination	ITS Technical	Recommended Approaches	Measures of Effectiveness
1	ITS program operation and technology selection need to be investigated and outlined to develop robust early program scope and cost estimates. Doing so requires considerable up-front effort—more than is typical for traditional transportation projects at the same stage.			✓	✓	✓
2	There is not enough cost or benefit information available to assist agencies in matching ITS programs with needs, with gaining support, and to help the MPOs integrate ITS into the transportation planning process.		✓	✓	✓	✓
3	Incorporating the experience and knowledge gained from other ITS implementations improves early program definition. Scanning tours are one method to learn from other agencies, and can help in understanding ITS benefits.			✓	✓	
4	Begin early to promote and develop coordinated regional operations and ATMS capabilities. Develop the ITS concept in a collaborative forum.		✓		✓	
5	Continuous interagency coordination from planning through operations and maintenance is critical to the success of integrated regional ITS deployments.		✓		✓	
6	ITS programs require more interagency coordination than typical for traditional transportation programs.		✓		✓	

ES.2.2 Design Phase

Table ES-2 presents the lessons learned from the NAVIGATOR experience during its design phase. Interagency coordination should be completely "achieved" prior to the commencement of this phase to enable success of this phase. Continued interagency coordination throughout this phase is also key to its success. Program management and ITS technical skills are critical during this phase. Thus, this phase requires very high levels of availability of all the three ITS skill areas. This can be satisfied through the provision of ample guidance, as suggested in the table.

TABLE ES-2
Lessons Learned—Design Phase

Ref. No.	Summary Point	ITS Skill Areas			Guidance	
		Program Management	Interagency Coordination	ITS Technical	Recommended Approaches	Measures of Effectiveness
7	Some agencies are more committed than others to ITS. It is a challenge to bring on those that have little pre-existing commitment to ITS concepts.		✓			

Ref. No.	Summary Point	ITS Skill Areas			Guidance	
		Program Management	Interagency Coordination	ITS Technical	Recommended Approaches	Measures of Effectiveness
8	Comprehensive operating agreements are essential in order to achieve the full benefits of an intermodal, interjurisdictional ATMS.		✓			
9	Law enforcement and other emergency services agencies will likely realize measurable benefits from participation in integrated incident management systems. Once they are able to actually see an ATMS in action, and how it benefits their own operations, they often become highly supportive of integrating with the regional ATMS operations.		✓			
10	There is a lack of guidance to support interagency coordination and decision-making for ITS programs. Different agencies often support different decision-making approaches.		✓		✓	
11	There is a lack of guidelines for the development of Concept Plans for ITS deployments. Since Concept Plans are the first step in overall ATMS deployment, they are critical to overall program success.	✓		✓	✓	✓
12	Field device implementations can generally be adapted to traditional PS&E processes. Modifications to the low-bid field device procurement process will better ensure proper field device performance and functionality.	✓		✓		✓
13	It is difficult to gauge progress in software development. In addition, there are many difficulties in translating a non-automated process to an automated one. The program management skills needed for ITS programs that include work outside of the traditional transportation staff's expertise, such as software development, are different from the skills needed to manage consultants performing work that the transportation staff is expert in. Therefore, custom-designed and developed software can represent the highest cost and schedule risk for an ITS program.	✓		✓	✓	✓
14	Prototyping early and often is critical to software development success.	✓		✓	✓	✓
15	There are no standard guidelines in place at transportation agencies to help guide software development and mitigate risks.	✓		✓	✓	✓
16	Design and implementation of a complex control system incorporating multiple untried technologies is highly risk-prone since adequate prior experience is not available.	✓		✓	✓	
17	There are no processes in place at transportation agencies to guide configuration management of control systems.	✓		✓	✓	
18	The funding structure for ITS programs promotes adoption of the latest technologies because there are few funds available for future technology upgrades. This may result in late changes to the control system. If there are schedule pressures, late changes may affect the ability to complete the control system within the needed time frame.	✓		✓		✓
19	There is no guidance for the development of Systems Engineering Management Plans which, when well designed and followed, are critical to ensuring proper system integration.	✓		✓	✓	
20	To help manage and integrate multiple contracts, a Systems Integrator contract can be used. To facilitate coordination among multiple contracts, weekly meetings (with FHWA or FTA support as a facilitator) can be a highly effective tool.	✓	✓		✓	
21	ITS programs include components that present special regulatory and technical challenges that are not found in traditional transportation programs.			✓		✓

Ref. No.	Summary Point	ITS Skill Areas: Program Management	ITS Skill Areas: Interagency Coordination	ITS Skill Areas: ITS Technical	Guidance: Recommended Approaches	Guidance: Measures of Effectiveness
22	TMC building design and project management requires specialized expertise not typically found within traditional transportation agencies. Transportation agency construction standards differ from those in the building construction industry, and are difficult to adapt to building contract needs.	✓			✓	✓
23	Program management of complex ITS programs requires tools not typically available at traditional transportation agencies. Processes and standards developed for traditional transportation works do not address the specific needs of ITS programs.	✓			✓	✓

ES.2.3 Consultant Services Procurement Phase

Table ES-3 summarizes the lessons learned during the consultant services procurement phase. ITS program management and recommendation of approaches to achieve success are very critical for success in this phase. Interagency coordination is expected to be "achieved" upon completion of the previous phase, but it is a continuing need for successful procurement of ITS components.

TABLE ES-3
Lessons Learned—Consultant Services Procurement Phase

Ref. No.	Summary Point	ITS Skill Areas: Program Management	ITS Skill Areas: Interagency Coordination	ITS Skill Areas: ITS Technical	Guidance: Recommended Approaches	Guidance: Measures of Effectiveness
24	Many ITS components are difficult to incorporate into standard transportation-air quality models.			✓		✓
25	ITS programs should be incorporated into regional transportation plans.		✓		✓	✓
26	If transit ITS programs are not considered as part of the usual budget and funding cycle then special FTA grant agreements may be required that can introduce other funding conditions and funding schedule issues.	✓			✓	
27	The current Federal-aid (roads) funding processes and Federal-local (transit) funding relationship work for ITS.	✓	✓			
28	Coordinating the management of a multiagency regional ATMS program can be simplified if a single agency is selected by the ATMS partners to manage the program.	✓	✓		✓	
29	Traditional local transportation agencies may have little ITS technical and program management skills and experience necessary for successful deployments. They may rely on outside support from peer organizations, outside experts, and the FTA and FHWA.	✓	✓	✓	✓	✓

Ref. No.	Summary Point	ITS Skill Areas			Guidance	
		Program Management	Interagency Coordination	ITS Technical	Recommended Approaches	Measures of Effectiveness
30	The traditional Federal-local and transit program oversight and review relationship can be adapted to complex ITS deployment programs. Daily interaction can result in improved coordination and technical support, and reduced review time.	✓	✓			
31	Many road agencies do not bring on outside program management assistance, and may overlook the funding needs for such assistance.	✓			✓	
32	Many traditional transportation agencies experience difficulties in creating and funding new positions needed to manage an ITS program, and rely on existing staff or outside assistance.	✓			✓	
33	The proportion of life-cycle costs including cost to deploy devoted to operations and maintenance are higher for ITS than for traditional transportation projects. Thus, operations and maintenance funding is even more important to ITS than to traditional transportation projects.	✓			✓	
34	Even if adequate staff are available to support ITS operations and maintenance, they may require initial and on-going training in specialized ITS skills. This initial training could consume considerable resources and could take longer than expected.			✓		
35	Difficulties in recruiting, paying competitive salaries, and retaining staff have led agencies to use outside operations and maintenance service providers.	✓		✓	✓	
36	Agency staffing policies are often not flexible enough to allow agencies to readily create the specialized staff positions required for ITS operations and maintenance. The process often requires political and top management support.	✓				
37	A regionally integrated ATMS may benefit from regionally coordinated operations and maintenance. However, the long-range funding commitments necessary to create a coordinated funding pool are difficult to obtain.	✓	✓			
38	An earlier understanding of the staff needs for operations and maintenance may have helped agencies create and fund staff positions (if needed).	✓		✓	✓	
39	The complete scope of work for an ITS program, such as NAVIGATOR, cannot be defined until after the system concept and functional requirements are developed.	✓	✓	✓	✓	✓
40	Procurement processes developed for traditional transportation programs are not well suited to complex ITS programs, particularly the software and systems integration portion of the contracts.	✓			✓	
41	Transit agencies have procured systems in the past, and have developed procurement policies and guidelines appropriate to ITS systems needs. Due to this, transit agencies' and FTA procurement guidelines are more flexible when procuring technology-based systems than those of road agencies. Road agencies are less experienced with system procurements and often do not have appropriate contracting mechanisms.	✓			✓	
42	Using fixed-price contracts for ITS systems work may constrain the program because the scope is hard to clearly define up front, and the decisions made during the system design portion of the work may affect the overall cost.	✓			✓	

ES.2.4 Construction Phase

The construction phase lessons learned and the associated skills requirements and guidance needs identified are presented in Table ES-4. Program management is the most important skill needed in this phase as the design is completed and sufficient interagency coordination has already been achieved during the earlier phases. Provision of guidance on procedures will ensure swift and successful construction completion.

TABLE ES-4
Lessons Learned—Construction Phase

		ITS Skill Areas			Guidance	
Ref. No.	Summary Point	Program Management	Interagency Coordination	ITS Technical	Recommended Approaches	Measures of Effectiveness
43	Construction plans for field devices need to be well coordinated and planned to ensure that they result in a complete, integrated system. The plans must be checked to ensure they form a complete system, and this should be the responsibility of a single contact.	✓			✓	
44	Field device construction can follow typical PS&E processes successfully.	✓			✓	
45	The roles and responsibilities of outside consultants brought on as building construction managers must be clearly defined and understood—Are they acting as agents for the transportation agency with all the responsibility and decision-making authority of agency staff, or are they serving in an advisory role?	✓			✓	

ES.3 SUMMARY

Despite the lack of pre-developed guidance, GDOT and MARTA and the other ITS partners were able to implement a complex, regionally integrated ITS in a highly compressed time frame. FHWA staff estimate that a similar program, if implemented without the schedule constraint present in Atlanta, would have taken at least 10 years to accomplish. NAVIGATOR was achieved in 5 years, despite the fact that the partners were the first in the United States to implement such a system, and despite the difficulties of attempting to adapt standards developed for traditional transportation programs. Future ITS programs can benefit from the following recommendations that are based on the NAVIGATOR experience.

ES.4 RECOMMENDATIONS

The following recommendations are made to support the needs presented in the five major findings, and to improve implementation of ITS programs throughout the United States. They can be divided into two areas: recommendations regarding the execution of ITS programs, and recommendations for the development of further guidance for ITS programs.

ES.4.1 ITS Program Execution

One of the key lessons learned in Atlanta is that road transportation agencies must amend their view of projects to better support ITS deployments. The first step toward that change is to modify practices to fit ITS projects, rather than attempting to make ITS projects fit practices designed for traditional transportation works. It is also important to retain practices that work well for both traditional transportation and ITS projects. In particular, the Federal-local and transit agency relationships work well, as do the processes in place for program funding.

ITS deployments can be divided into four major steps. Each major step presents different technical and program management needs and challenges. The overall goal of the suggested project approach outlined herein is to support these needs, ensuring that the appropriate resources are available at all agency levels.

The four main steps for ITS deployment are:

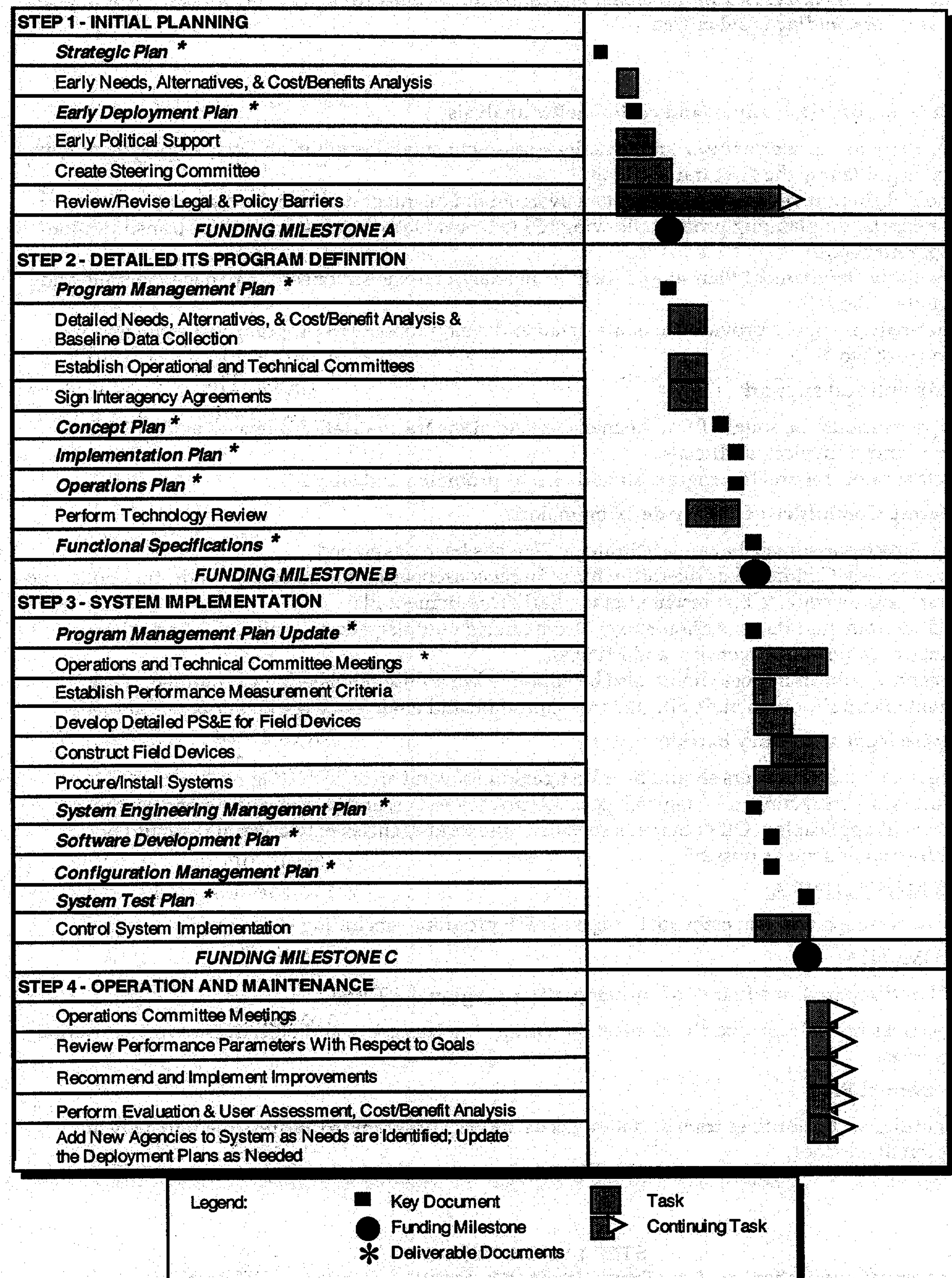
- Step 1—Initial Planning
- Step 2—Detailed ITS Program Definition
- Step 3—System Implementation
- Step 4—Operation and Maintenance

Figure ES-1 shows the four major steps, and the tasks and deliverables within each step. It is intended to provide overall guidance as to what tasks should be considered when deploying ITS, particularly multiagency ITS program execution. No specific time scale is provided, but relative task dependencies are shown. The overall progress of each task in relation to the others is the important part of the recommendation. It is important to complete all the tasks in a step before moving on to the next step.

Following Figure ES-1, each of these steps is described in detail. For each step, desired outcomes are specified, tasks to achieve the outcomes are described, the funding milestone is defined, and key documents of the step are listed.

At the bottom of each step description, the level of need for the three skill areas (Interagency Coordination, Program/Project Management, and ITS Technical) are rated as high, medium, or low. The skill level rating is described with respect to the baseline skills typically found at traditional road and transit agencies.

FIGURE ES-1
The Steps Toward Regional ITS Development



STEP 1: INITIAL PLANNING

Outcomes: *ITS is integrated into regional multimodal transportation planning process. Application for funding is submitted.*

TASKS:

Perform early needs, alternatives, and cost/benefits analysis

- The early needs, alternatives, and benefits assessment should result in an Early Deployment Plan that is guided by the ITS Strategic Plan.
- The ITS alternatives and cost/benefit analysis should be integrated into the regional transportation planning process, allowing ITS to be evaluated against traditional transportation program needs.
- The Early Deployment Plan should include an analysis of the staff need to manage, operate, and maintain the ITS.
- The analysis should provide adequate detail to develop robust ITS program cost estimates and scopes of work.

Obtain early political support

- Support should be sought from the management at the transportation agencies at the highest level, and from elected officials.
- Staff support for an ITS program should also be promoted and created.

Create Steering Committee of agency decision makers

- This process assumes that an ITS Strategic Plan has been developed.
- The Steering Committee is the forum for creating consensus on the basic ITS needs, functions, and operating concepts to be presented in the Early Deployment Plan.
- Include transportation decision makers from affected municipalities, police, fire, and other emergency response agencies, and MPO(s).
- Technical subcommittees should also be appointed to advise the Steering Committee. Their membership should include affected transportation and emergency response operations staff.

Review/revise legal and policy barriers

- Legal and policy barriers should be investigated in several areas including procurement processes, contracting, tow dispatch policies, privacy issues, and public-private partnership issues (if applicable). Other barriers specific to the local agencies may arise, and should be addressed as soon as possible.

FUNDING MILESTONE A:

- Develop scope and cost estimate to fund the ITS program—including staff needs.

KEY DOCUMENTS:

Strategic Plan (Prepared in advance of contemplating a regional ATMS)

- Describes how ITS programs can meet the vision, mission, goals, and objectives of transportation agencies.

Early Deployment Plan

- Identifies and prioritizes transportation needs and ITS programs to address them in a given region or corridor.

STEP 1 SKILL NEEDS:

Interagency Coordination			Program/Project Management			ITS Technical		
LOW	MED	HIGH	LOW	MED	HIGH	LOW	MED	HIGH

STEP 2: DETAILED ITS PROGRAM DEFINITION

Outcomes:

- ***Adequate information is provided for affected agencies and others to understand system functions and field device locations.***
- ***Interagency agreements regarding operations and maintenance are signed.***
- ***Cost estimates are refined.***
- ***Baseline data is collected.***

TASKS:

Detailed needs, alternatives, benefits and cost evaluation, and baseline data collected

- Develop more detailed evaluation of ITS program and components.
- Establish expectations of system benefits and gather baseline data for future performance evaluation.
- Perform a risk assessment, and establish contingency plans if needed.
- Incorporate non-ITS traffic and incident management techniques into the program to maximize performance.
- Provide input to the Concept Plan.

Establish operations and technical committees

- The operations committee develops consensus on how the ATMS addresses on-street operations such as accident response plans, traffic diversion plans, and ramp meter/traffic signal coordination plans. This provides input to the Concept Plan and Operations Plan.
- The operations committee also establishes a coordinated maintenance plan for the regional system, including determining appropriate shares for funding maintenance activities.
- The technical committee establishes Functional Specifications and focuses on the review of hardware and software options to meet them.

Sign interagency operating and maintenance agreements

- Detailed operations and maintenance agreements are developed and executed between ITS member agencies.

Perform technology review

- Prepare an alternatives analysis and evaluation of field devices and control system components. This provides input to the Concept Plan and Functional Specifications.

FUNDING MILESTONE B:

- Ensure that the originally programmed funds will continue to be adequate.

KEY DOCUMENTS:

Program Management Plan

- Describes how overall program management will be conducted, including schedule and cost tracking and management; how decision-making is performed; the responsibilities of the various affected agencies and their consultants; and communications protocols.

Concept Plan

- Includes alternatives, cost/benefit, risk, and contingency analyses.
- Provides preliminary details of field devices, preliminary operational and functional concepts, and field device technology selections.

Operations Plan

- Includes details of how the control system will function to meet the operational needs of the ATMS, including interagency protocols and user interfaces.

Functional Specifications

- Defines each of the control system functions necessary to meet the operational scenarios established in the Concept Plan. Identifies standards that must be met for the control system implementation, and includes an evaluation of alternative methods of providing control system functions.

Implementation Plan

- Divides the ITS program into distinct contractual components, and provides an implementation schedule. Identifies lead agencies for specific program components, and establishes project coordination needs. Identifies actual and planned funding sources for projects.

STEP 2 SKILL NEEDS:

Interagency Coordination	Program/Project Management	ITS Technical
LOW / **MED** / HIGH	LOW / MED / **HIGH**	LOW / MED / **HIGH**

STEP 3: SYSTEM IMPLEMENTATION

Outcomes: ***A functioning regional ATMS, meeting goals established in the previous steps, is deployed.***

TASKS:

Maintain operations and technical committees

- The operations and technical committees should be maintained, with the technical committee being most active at this time.

Establish performance measurement criteria

- Methods should be developed by the operations and technical committees to measure performance once the system is installed.

Develop detailed PS & E for field devices

- Develop bid documents for field devices including communications systems, cameras, vehicle detection devices, CMSs, etc.

Construct field devices

- Procure and install field devices per PS & Es.

Procure/install systems

- ITS systems, such as those for transit ITS including AVL, should be procured and installed at this time.

Control system implementation

- Based on the System Implementation Plan, the control system for the ATMS should be implemented.

FUNDING MILESTONE C:

- Ensure that future operations and maintenance needs are funded.

KEY DOCUMENTS:

Program Management Plan Update

- Update the Program Management Plan in light of the construction and implementation tasks that were identified in the previous program step. Include reference to the Software Development Plan and Configuration Management Plan.

Systems Engineering Management Plan

- Describes the methodology and milestones in systems integration, and control system development and testing.

Software Development Plan

- Describes the methodology and milestones in software development and testing.

Configuration Management Plan

- Provides protocol for and documentation of control system hardware and software changes.

System Test Plan

- Describes how proposed testing routines will ensure that the system functionality is as specified and to identify potential failures.

STEP 3 SKILL NEEDS:

Interagency Coordination	Program/Project Management	ITS Technical
LOW / MED / HIGH	LOW / MED / **HIGH**	LOW / MED / **HIGH**

STEP 4: OPERATION AND MAINTENANCE

Outcomes: ***Operation, maintenance, and continual improvement of the ITS is accomplished.***

TASKS:

Maintain operations committee

- Maintain operations committee to track ITS performance, maintain interagency relationships, evaluate proposals to modify system on-street operations, coordinate maintenance and training needs, and evaluate proposals to upgrade hardware, software, and field devices.

Review performance parameters with respect to goals

- Develop annual report of ITS performance with respect to performance goals.

Recommend and implement improvements

- Recommend improvements as suggested by the performance committee. Integrate ITS improvement needs into the regional transportation planning process.
- Perform continuous technology review to scan for potential upgrades to ITS.

Perform evaluation and user assessment

- Using the baseline data gathered in Task 2 - ITS Program Definition, perform an evaluation of system performance, including a cost/benefit analysis and a user (travelers and ITS partners) assessment of the system benefits.

Work to add new agencies to the system as needs are identified

- Identify appropriate additional regional ITS partners on the basis of current and projected transportation needs, and bring them into the program via interagency agreements.

FUNDING MILESTONE:

- Ensure that joint agency operations and maintenance contracts are signed and maintained to successfully obtain adequate funding for operations, maintenance, and system upgrades.

KEY DOCUMENTS:

- None identified for this report, although several documents including operating procedures, evaluation, and performance reports are necessary.

STEP 4 SKILL NEEDS:

Interagency Coordination

LOW	MED	HIGH

Program/Project Management

LOW	MED	HIGH

ITS Technical

LOW	MED	HIGH

ES.4.2 Guidance for ITS Programs

As stated earlier, specific guidance for ITS program conduct is needed. The recommendations presented here are intended to support the special needs of ITS deployment on a local or regional basis. Each agency can determine if its existing programs and policies comply with the strategies outlined. The agency can also determine the best ways to modify its programs and policies to better align itself with the ITS needs. Each agency's approach may differ somewhat from the recommendations presented below on the basis of its unique experiences and circumstances.

Recommendations to support the ITS Program Execution recommendations presented previously and ITS skills development are provided in Table ES-5 through Table ES-7. They provide recommendations for Federal and local agencies. The recommendations are grouped into three areas on the basis of the goals they address. The goals are related directly to the findings based on the Atlanta experience.

ES.5 ITS PROCEDURES

Successful projects generally are focused on deliverables or products and the steps and tasks necessary to produce them. The following recommendations are intended to help strengthen the focus on the essential "deliverables" of ITS projects and the ways to "produce" them.

TABLE ES-5
Develop Guidance for ITS Procedures
Federal and Local Level Recommendations for ITS Guidance Support

Goal of the Recommendations	Federal Level Recommendations	Local Level Recommendations
FINDINGS: Develop Guidance for ITS Procedures		
ITS Process Support	Develop guidance documents for the execution of ITS programs (the Steps to ITS). Encourage modifications to Federal assistance role for ITS programs to be more interactive, providing support and involvement on a day-to-day basis. Support the development of interagency operations and technical committees by providing guidance for committee goals and decision-making processes. Assist local agencies in establishing appropriate roles for consultant assistance. Are outside consultants working as independent experts, providing advice to the local agency, or are they acting as local agency "agents," supplementing staff? Provide performance measurement guidelines to assist local agencies with the development of ITS program performance measurement standards. FHWA should evaluate the system procurement process used by FTA, and, if appropriate, adapt it for use in procuring ITS systems. Provide support to local agencies to assist in the development of procurement processes that meet ITS needs in the form of case studies of other local agencies, guidance on selection of procurement processes (professional services, non-professional services, goods), and technical assistance to assess local agency procurement barriers. Provide support to local agencies to assist in the development of contracting mechanisms that meet ITS needs in the form of case studies of other local agencies, and technical assistance to assess local agency contracting barriers. Facilitate better incorporation of ITS programs into regional transportation plans by providing information regarding ITS costs and benefits, ITS transportation impact analysis tools, and air quality impacts of ITS to local agencies.	Institute ITS process guidelines including major review milestones. Create and maintain on-going ITS coordinating committees. Consider enlisting support from the local MPO to assist in committee activity coordination. Develop and institute ITS program performance measurement processes to monitor performance after ITS program deployment. Local agencies should review and resolve barriers to developing contract mechanisms that are well suited to the needs of ITS programs. Bring ITS program plans into the regional transportation planning process as early as possible.

ES.5.1 ITS Measures of Effectiveness

To understand how well an ITS program is progressing and how well it is achieving its intended objectives, there must be a basis for comparison. Implementation of the recommendations that follow will provide the documentation necessary to effectively plan ITS progress as well as track progress and measure the final "deliverables" against the program goals and objectives.

TABLE ES-6
Develop ITS Measures of Effectiveness
Federal and Local Level Recommendations for ITS Guidance Support

Goal of the Recommendations	Federal Level Recommendations	Local Level Recommendations
FINDINGS: Develop ITS Measures of Effectiveness		
Develop Standard Documents to Guide ITS Programs	Provide guidance to local agencies for the development of the following documents: • ITS Strategic Plan • ITS Early Deployment Plan • Program Management Plan • Concept Plan • Operations Plan • Functional Specifications • System Implementation Plan • Systems Engineering Management Plan • Software Development Plan • System Test Plan • Configuration Management Plan	Either follow Federal guidance if documents are prepared in-house, or clearly define requirements in contracts if outside assistance is used, for the following documents: • ITS Strategic Plan • ITS Early Deployment Plan • Program Management Plan • Concept Plan • Operations Plan • Functional Specifications • System Implementation Plan • Systems Engineering Management Plan • Software Development Plan • System Test Plan • Configuration Management Plan If no Federal guidance is available, use other ITS deployments elsewhere as examples.

ES.5.2 ITS Skills

Three of the five major findings of the study involve the need to enhance ITS technical skills. Without attending to these skills, an ITS deployment is likely to be difficult and may even fail. The following sets out specific recommendations to address skill needs.

TABLE ES-7
Improve Program/Project Management Skills, Interagency Coordination Skills, ITS Technical Skills Federal and Local Level Recommendations for ITS Guidance Support

Goal of the Recommendations	Federal Level Recommendations	Local Level Recommendations
Improve Program/Project Management Skills, Interagency Coordination Skills, ITS Technical Skills		
ITS Skill Area Support	Promote capacity building for Federal and local staff in the areas of interagency coordination, program management, and ITS technical skills. Assist local agencies in the assessment of skill area strengths and needs. Provide access to national public and private sector leaders in ITS technology. Support local agency efforts to supplement staff needs internally. Support local agency efforts to supplement staff needs externally.	Provide capacity building for ITS staff in the areas of interagency coordination, program management, and ITS technical skills. Consider teaming with local MPOs or other regional forum to enhance interagency coordination. Assess agency skill area strengths and needs at the early ITS program definition stage—including staff needs for operations and maintenance. Develop external support network of national ITS public and private sector technology leaders. Begin early to identify and resolve barriers to the creation of appropriate internal ITS staff positions. Begin early to identify and resolve barriers to using outside support contractors to provide appropriate ITS skills.

These recommendations provide high-level suggestions for improving ITS deployments. They are a starting point, and should be adapted to the conditions found at the location considering ITS deployments.

ES.2 ACKNOWLEDGEMENT

The Atlanta region's transportation agencies faced and met a huge challenge in deploying a multiagency, multimodal, and highly advanced ITS program in a short time period—while bearing the additional burden of preparing for the Olympic and Paralympic Games. It is only through their open and generous attitude that this Case Study was accomplished. They should be viewed as true innovators and champions of ITS. By documenting their experiences and achievements, other agencies have gained an unparalleled wealth of experience. Because the Atlanta agencies looked on their experiences in hindsight, they were able to make suggestions for improvement. The agencies were highly successful and achieved a remarkable level of technological and interagency functionality, which is, at the time of this report, unparalleled in the United States. The successes of the Atlanta ITS partners can be shared through implementing these recommendations.

1.0 INTRODUCTION

The Atlanta, Georgia, metropolitan region is the location of one of the most ambitious Intelligent Transportation Systems (ITS) deployments in the United States. The system includes a Transportation Management Center (TMC), six Traffic Control Centers (TCC), and a Transit Information Center (TIC) linking eight regional agencies. In addition, regional Advanced Transportation Management Systems (ATMS) including incident management, regional Advanced Traveler Information Systems (ATIS), and Advanced Public Transportation Systems (APTS) were installed. The 1996 Summer Olympic and Paralympic Games, held in Atlanta, created a focus for the projects. The goal was to bring all of the new systems on line in time for the games. Collectively, this program is referred to as NAVIGATOR.

The games also served as a focus for an extension of the area's High Occupancy Vehicle (HOV) lane system, and of the Metropolitan Atlanta Rapid Transit Authority (MARTA) rail network.

The Atlanta region's transportation agencies faced and met a huge challenge in deploying a multiagency, multimodal, and highly advanced ITS program in a short time period—while bearing the additional burden of preparing for the Olympic and Paralympic Games. It is only through their open and generous attitude that this Case Study was accomplished. They should be viewed as true innovators and champions of ITS. By documenting their experiences and achievements, other agencies have gained an unparalleled wealth of experience. Because the Atlanta agencies looked on their experiences in hindsight, they were able to make suggestions for improvement. Simply because they have identified potential for improvement does not lessen their accomplishment. They were highly successful and achieved a remarkable level of technological and interagency functionality, which is, at the time of this report, unparalleled in the United States. The successes of the Atlanta ITS partners can be shared through implementing these recommendations.

1.1 PURPOSE AND STRUCTURE OF THE CASE STUDY

What distinguishes the NAVIGATOR deployment from others in the United States was the regional, multimodal scope of the deployment and the firm operational deadline imposed by the 1996 Olympic and Paralympic Summer Games. The NAVIGATOR Case Study focuses on the institutional, programmatic, and technical issues and opportunities found in planning and implementing the NAVIGATOR systems. The purpose of the Case Study is to document those issues and opportunities on the basis of interviews, focus groups, and documentation reviews, and to present recommendations to be considered at Federal, State, regional, and local levels for future ITS deployments. The Case Study responds to the question *"What can be learned from the Atlanta experience to improve other ITS deployments in the future?"*

This report has been structured into five sections:

- Introduction
- Description of ITS and infrastructure deployments in Atlanta
- Timeline—a chronology of events related to NAVIGATOR
- Achieving NAVIGATOR—a discussion of the issues and challenges
- Recommendations

Two other reports have recently been prepared by Booz·Allen & Hamilton (BA&H) that relate to the NAVIGATOR deployment—the 1996 Olympic and Paralympic Games Event Study and the Olympic Spectator Transportation System (OSTS) Management, Operations, and Maintenance Review Study. Both reports focus on the operational issues encountered during the Olympic and Paralympic Games.

The Event Study and the Case Study are both being prepared for the Federal Highway Administration (FHWA) (with oversight from an executive committee with members from the Georgia Department of Transportation (GDOT), the Federal Transit Administration (FTA), the Atlanta Regional Commission (ARC), and MARTA. These two reports are interrelated, as described in Section 1.2 below. The OSTS Management, Operations, and Maintenance Review Study has been prepared by BA&H for the FTA. It is a detailed evaluation exclusively of the OSTS, and is not related to this Case Study.

1.2 OVERVIEW OF THE EVENT STUDY AND THE CASE STUDY

While this report contains information regarding events critical to the NAVIGATOR deployment leading up to the 1996 Olympic and Paralympic Games, the Event Study evaluates the actual operations of the ITS systems.

1.2.1 The Event Study

The key components of the Event Study are:

- Commentary on the size of the Olympic and Paralympic Games, in relation to other events
- Documentation of the effectiveness of the events' transportation management plans—targets versus actual outcomes
- Lessons learned—covering technical, operational, and institutional areas
- Evaluation of effectiveness of transportation management components, e.g., incident management, Georgia Department of Transportation's Highway

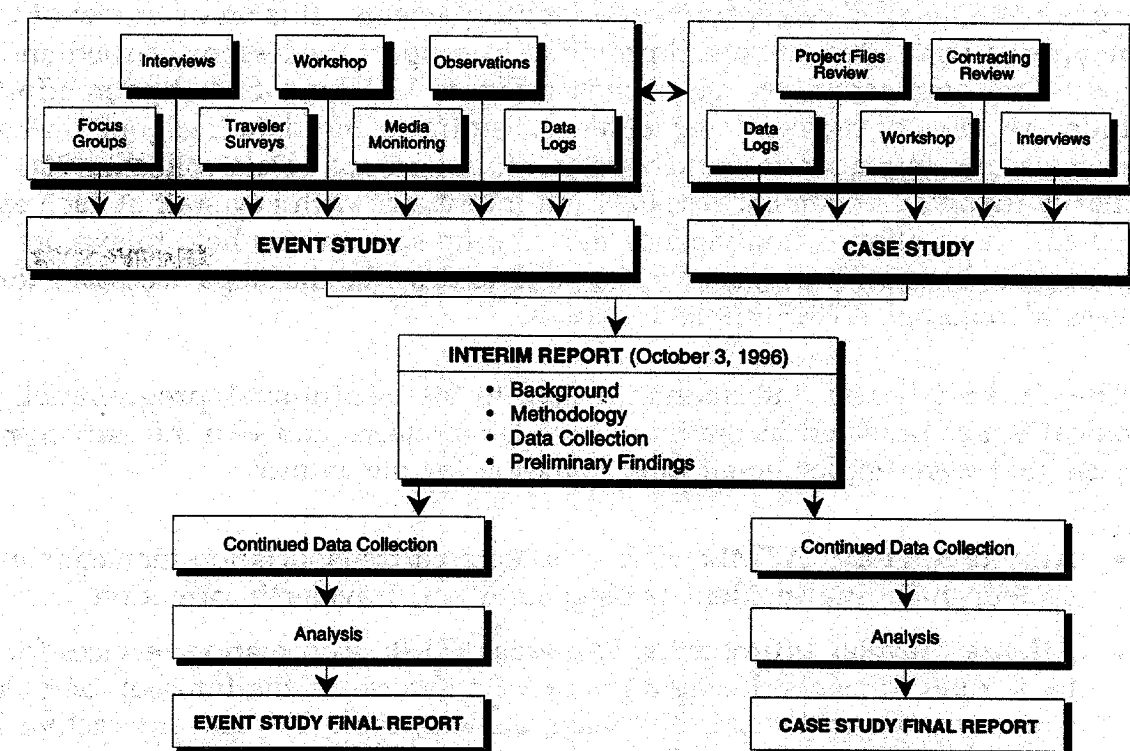
Emergency Response Operators (GDOT HEROs), APTS, ATIS, HOV lanes, and Travel Demand Management (TDM)

- Recommendations that may be applied to other locations for ITS deployment and staging special events
- Workshops and presentations about the transportation experience at the Olympic and Paralympic Games

1.2.1.1 Scope of Event Study

The scope of the Event Study essentially limited data collection to the duration of the Olympic and Paralympic Games. This limitation precluded any before and after comparisons against baseline conditions. The Event Study considers performance against expectations (where such expectations exist) and seeks to learn lessons that may be applied elsewhere—particularly where Federal funds may be used for similar systems or events. Figure 1-1 presents the Event Study and Case Study work flow. The data collection efforts for the Event Study included interviews, an interagency workshop and focus groups, and other elements. Much of the information gathered during the Event Study related to the development of the regional ATMS. Thus, it was pertinent to the Case Study, and is included herein.

FIGURE 1-1
NAVIGATOR Event Study and Case Study—Work Flow



1.2.2 The Case Study

The key components of the Case Study are:

- History of NAVIGATOR and other transportation operational improvements—a timeline describing key events
- Findings from the Atlanta experience—technical, programmatic, and institutional
- The "Ideal World"—a description of how ITS deployment might be accomplished efficiently and effectively in the future

1.2.2.1 Scope of Case Study

The Case Study seeks to develop recommendations to guide future ITS deployments on the basis of the lessons learned from each agency involved in the ITS deployments in Atlanta. The time period evaluated spans between 1990 and the opening day of the 1996 summer Olympic Games.

The Case Study naturally focuses on the interagency relationships required for a regional ATMS deployment. While technical issues are discussed, their primary purpose is to illustrate interagency coordination and programmatic issues. This case study is not a detailed reconstruction or audit of events. It is an overview of the deployments with adequate detail provided to support the lessons learned and suggested recommendations. As shown in Figure 1-1, the data collection effort included reviews of project documentation, contracts and data logs, one-on-one interviews, and interagency workshops and focus groups. Data collection has primarily involved document research and interviews with key staff at each agency involved. In addition, a multiagency focus group session was held to explore organizational issues, interagency issues, and to describe the steps necessary for a successful regional ATMS implementation.

The Case Study uses information related to the institutional, programmatic, and technical issues involved in the five major ITS projects, and two infrastructure projects that were implemented in preparation for the games:

- **Atlanta Regional ATMS:** A fully integrated transportation management system including incident management and traveler information
- **Atlanta Traveler Information Showcase (TIS):** Information services for individual travelers during and after the games via the Internet, personal communications devices, in-vehicle devices, cable TV, and interactive TV

- **ITS MARTA '96:** Public transportation improvements using various technologies, including Automatic Vehicle Location (AVL) devices, Automatic Passenger Counting Devices (PCDs), and Passenger Information Devices (PIDs)
- **Atlanta Kiosk Field Operational Test (FOT):** Provides information to travelers in Georgia using a network of 100 kiosks in the Atlanta metropolitan area and 30 more statewide
- **Atlanta Driver Advisory System (ADAS) FOT:** Provided information to 100 Federal Express and 100 GDOT vehicles within the Atlanta metro area through in-vehicle devices—this test was not operational during the games
- **HOV Lanes:** Infrastructure improvement for increased capacity on urban freeways
- **North Line Rail Extension:** MARTA rail extension into Atlanta's northern suburbs, with three new intermodal rail stations.

These projects are more fully described in Sections 2.1 (ITS projects) and 2.2 (non-ITS projects).

1.3 TRANSPORTATION CONTEXT

This section describes the Atlanta region and its transportation system for the purpose of placing the study in context. A brief overview of the NAVIGATOR systems is provided in Section 1.4.

1.3.1 The Atlanta Metropolitan Region

The Atlanta Metropolitan region comprises a 10-county area (Figure 1-2), which has seen sustained population and employment growth since 1970. The growth has pushed the edges of the urbanized region further out from the City of Atlanta. Since 1980, population growth in the Atlanta region has focused on the five "inner ring" counties (Clayton, Cobb, DeKalb, Fulton, and Gwinnett), excluding the City of Atlanta. Growth rates in the five inner ring counties have averaged 2.5 percent per year. The population of the City of Atlanta has declined slightly in the same period. The five "outer ring" counties have grown at nearly 5 percent per year since 1980.[1] Employment growth has followed similar trends.

The population growth trend is forecast to continue through the first decades of the next century, with much of the growth directed to the north of the City of Atlanta (Figure 1-3). Figure 1-4 provides current and forecast regional population and employment levels. Between 1990 and 2010 the region's population is forecast

[1] Vision 2020 Baseline Forecasts, Atlanta Regional Commission, June 1994.

FIGURE 1-2
The Atlanta Metropolitan Region

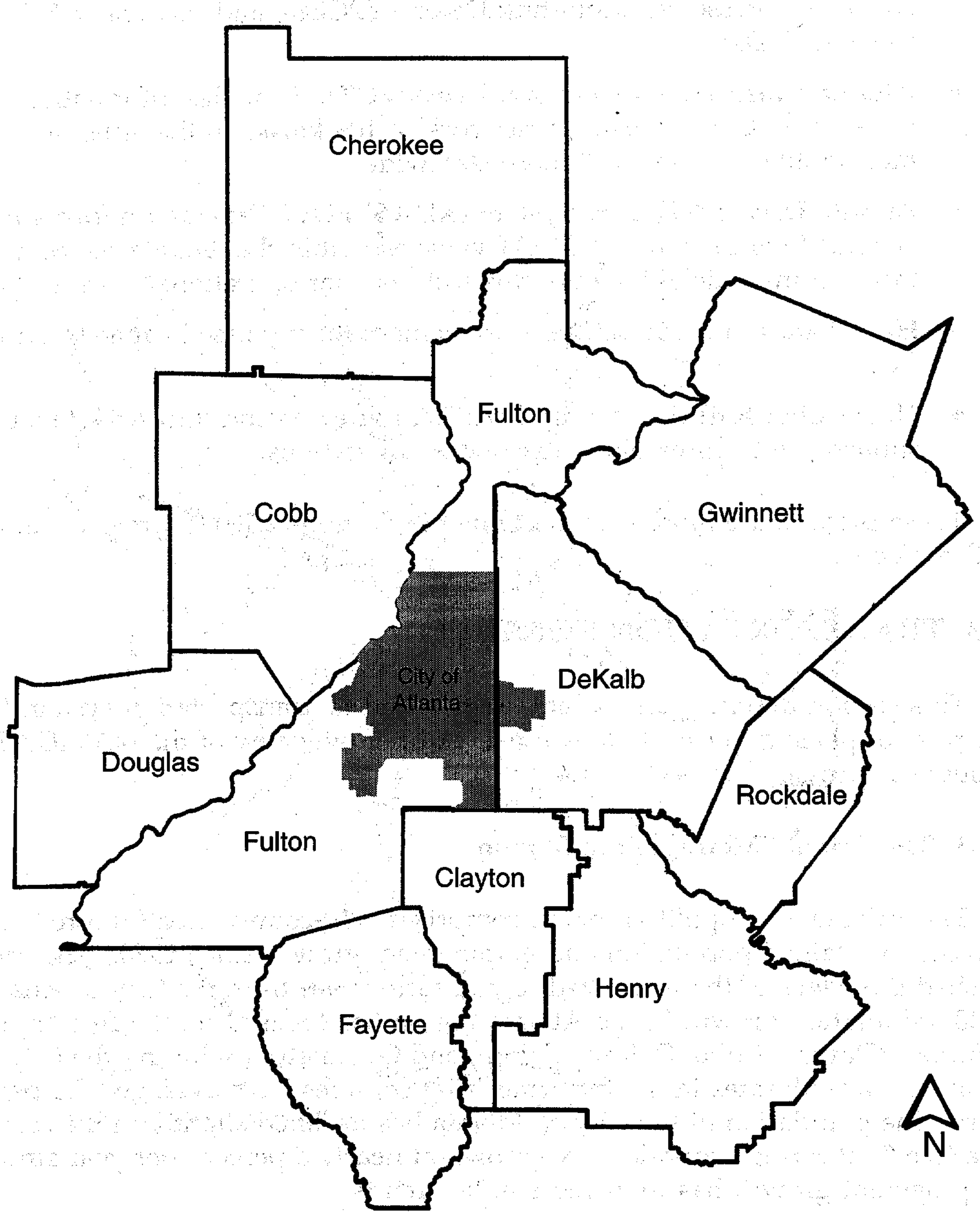
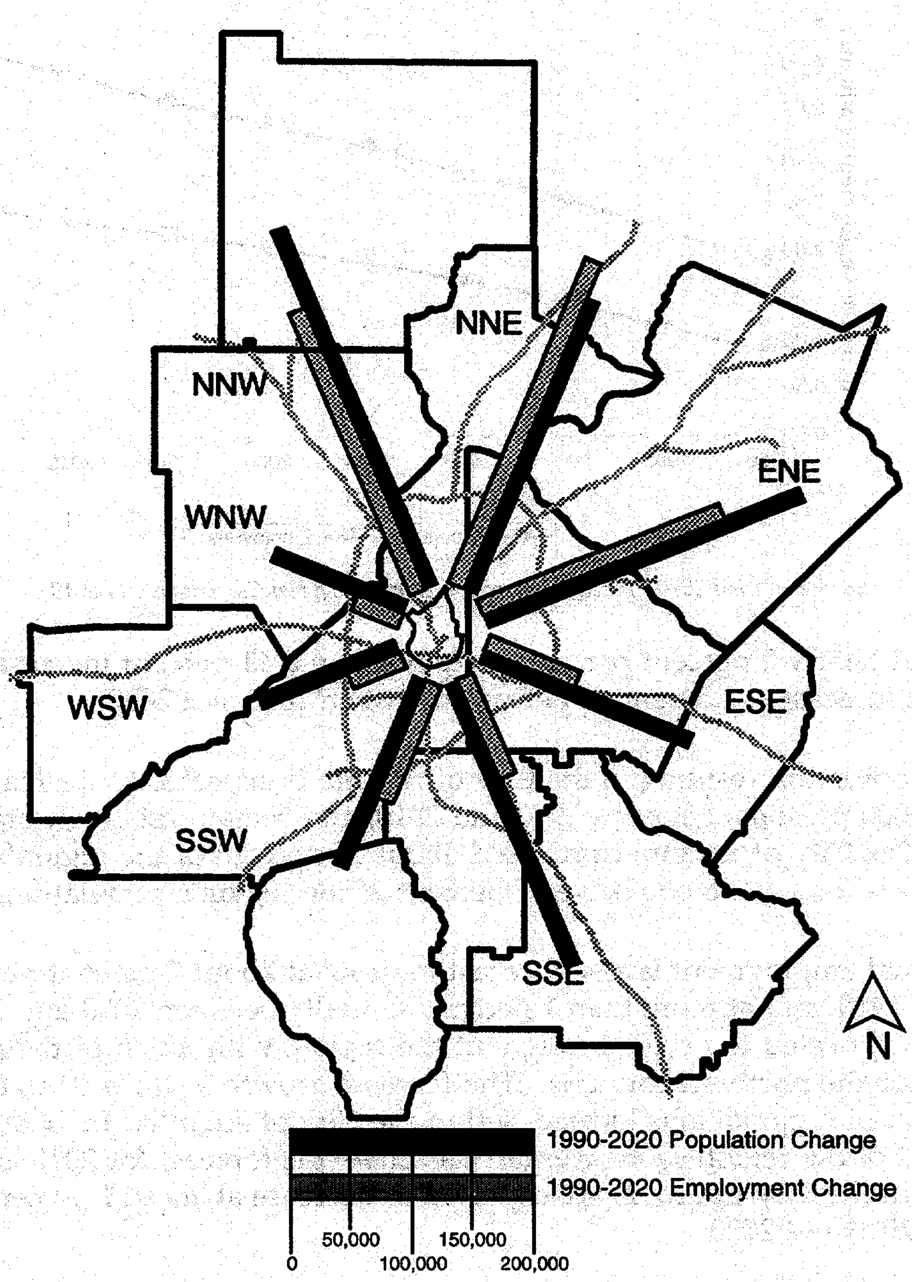
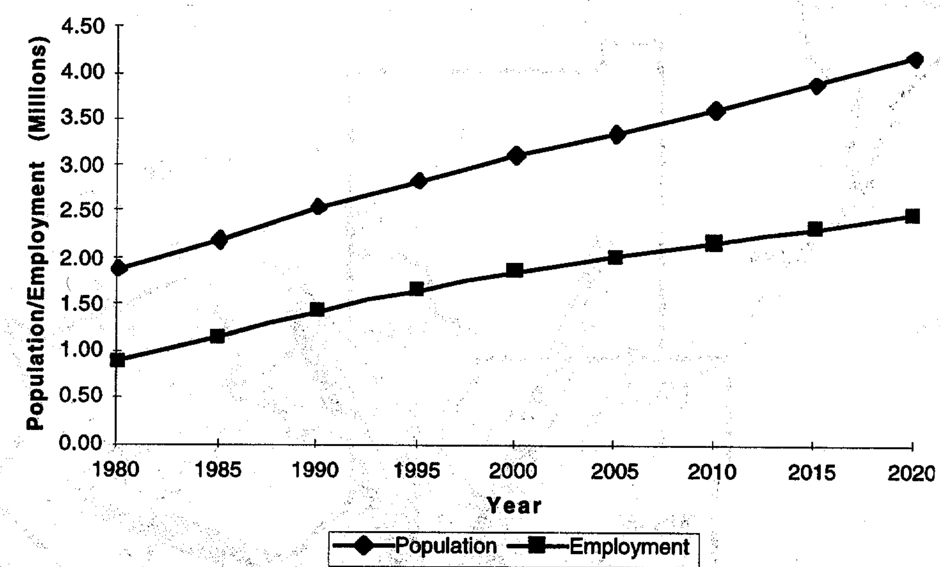


FIGURE 1-3
Regional Population and Employment Growth Projections (1990-2020)
Directions of Growth



Source: Vision 2020 Baseline Forecasts, Atlanta Regional Commission, June 1994

FIGURE 1-4
Historical and Forecast Population and Employment in the Atlanta Region 1985-2020



Source: Vision 2020: Baseline Forecasts, Atlanta Regional Commission, June 1994

to grow at nearly 2 percent per year—resulting in a 41 percent increase. Population growth is forecast at 1.5 percent per year between 2010 and 2020.

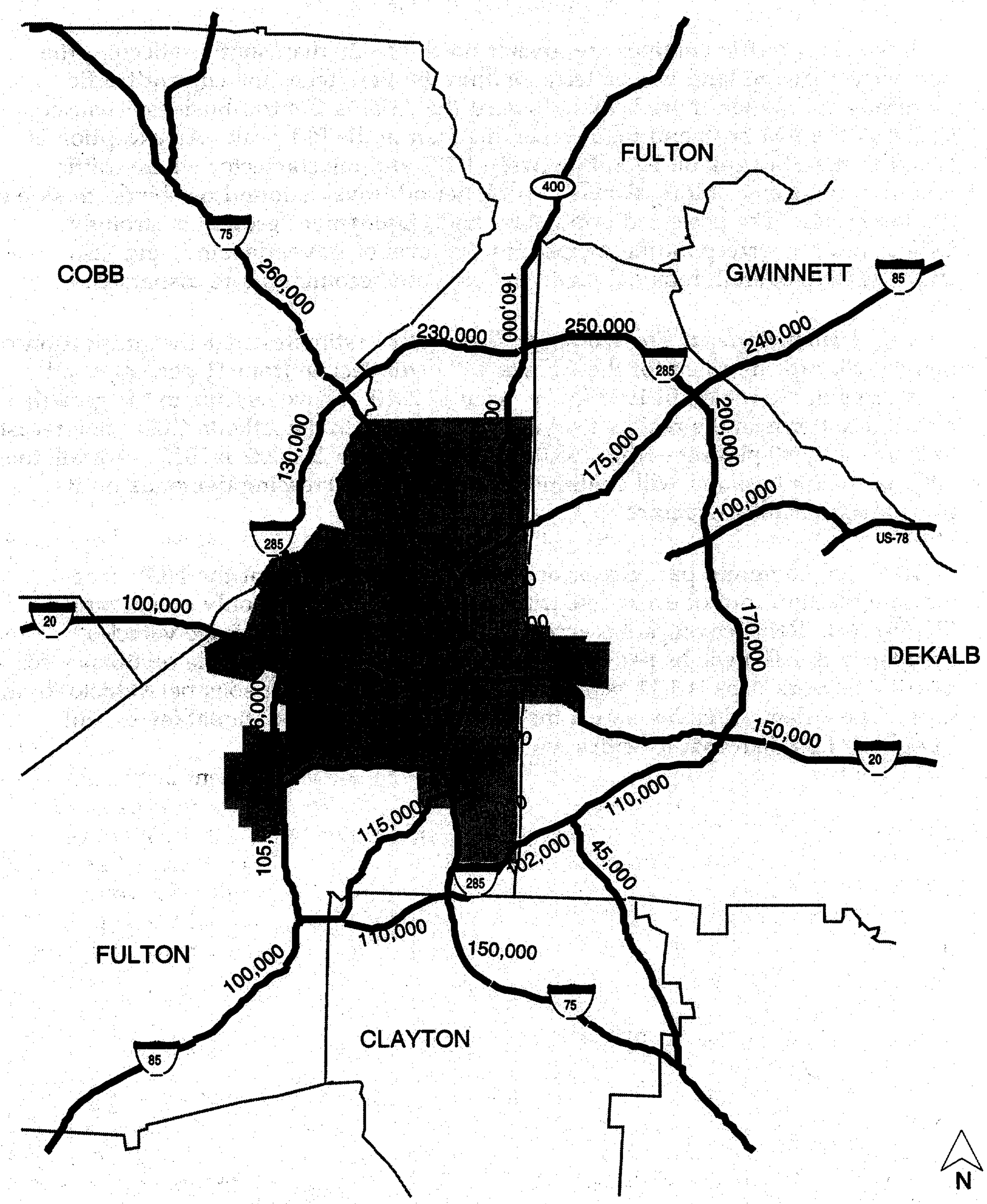
The population residing in the City of Atlanta is expected to decrease slightly (by about 10,000 persons) between 1990 and 2010, and remain relatively stable until 2020. In 1990, The City of Atlanta comprised about 16 percent of the region's population. In 2010, it is forecast to comprise 11 percent of the region's population.

Regional employment is also forecast to grow at about 2 percent per year between 1990 and 2010, and at more than 1 percent annually between 2010 and 2020. Job growth is expected to occur throughout the region, with much of the increase forecast for the northern counties. The forecast growth will result in a shift in the proportion of regional jobs located within the City of Atlanta. In 1990, about 28 percent of the region's jobs were in the City—the forecast for 2010 is 19 percent. Jobs within the City's borders are expected to decrease at about 1 percent per year between 2010 and 2020.

1.3.2 Regional Travel Demands

Figure 1-5 provides a schematic of the regional freeway system with approximate 1995 AADT traffic volumes. The regional freeway system includes I-75, a NW/SE directional freeway, and I-85, a NE/SW directional freeway. I-75 and I-85 meet in the Atlanta Central Business District (CBD) in an approximate 12.88 km section known as the Connector. I-20, an east-west regional freeway, intersects the Connector just

FIGURE 1-5
Approximate 1995 AADT on Area Freeways



Source: GDOT Georgia Traffic Map 1996

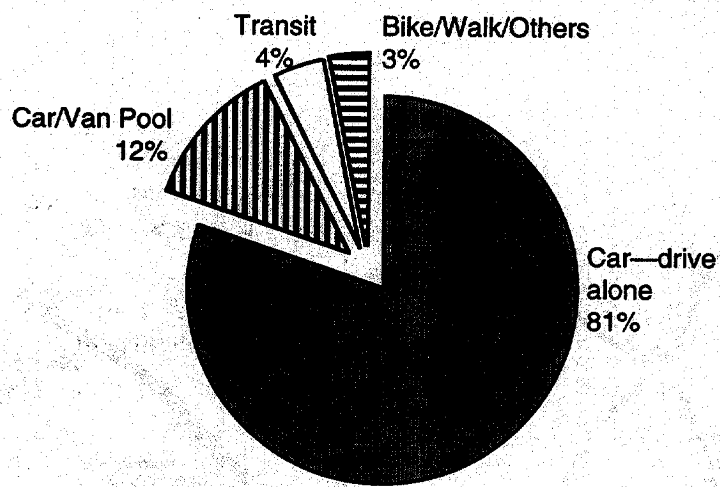
south of the CBD. I-285 is a circumferential road with an approximate 24.15 km east-west and an approximate 32.20 km north-south diameter. I-285 is also known as the Perimeter.

In general, traffic volumes are greater north of I-20 than south, reflecting the northerly growing land use pattern. Within the Perimeter, the current traffic patterns are oriented more heavily toward the Atlanta Central Business District (CBD) in the AM peak and the reverse direction in the PM peak. An exception is found in the PM peak on I-75 SB between I-285 and the connector where traffic volumes are heavy. More dispersed peak period travel is found on the north side of the Perimeter. The projected population and employment growth is strongly indicative of a corresponding increase in the level of travel demand, and also suggests that, overall, regional travel patterns are becoming more dispersed.

The *Atlanta Regional Transportation Plan: 2010* estimates that the proportion of daily work trips destined for the Atlanta CBD will decline from 11 percent of all work trips in the region in 1980 to 7 percent in 2010. However, due to the growth rate and patterns in the region, total daily work trips to the Atlanta CBD are forecast to increase by 40 percent—from 168,000 trips in 1980 to 236,000 in 2010. Overall, the Atlanta region has, and will continue to experience, increasing demands on its transportation infrastructure.

Regional commute patterns prior to the implementation of the HOV lanes indicate that four out of every five trips are made by car with only one occupant (Figure 1-6). Reliance on cars is accentuated by the fact that average vehicle occupancy is 1.12 persons per vehicle. The national average vehicle occupancy for journey-to-work trips is 1.11 persons per vehicle, and 1.61 persons per vehicle for all trips. The Atlanta region's transit modal split is similar to national levels, but somewhat less than that for cities with heavy rail systems.

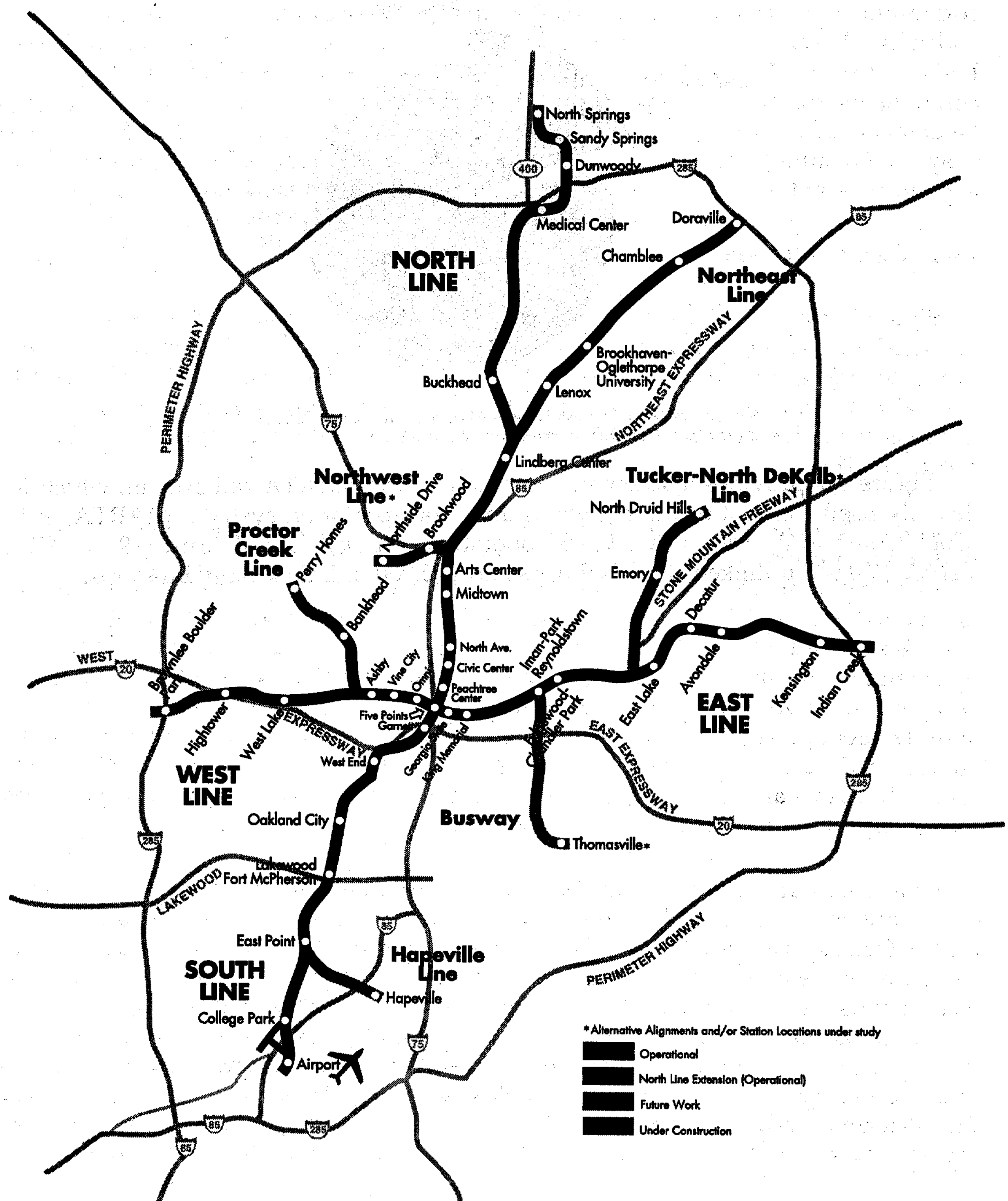
FIGURE 1-6
1995 Regional Commute Patterns Modal Split



Source: Atlanta Express Lanes—Market Strategies & Potential Utilization, COMSIS Corporation, August 1996

Figure 1-7 provides a schematic overview of the MARTA rail system, which is a heavily used element of the regional public transportation system. MARTA and Cobb Community Transit (CCT) also operate bus transit. As of April 1995, MARTA served 230,000 unlinked daily rail trips and 252,000 unlinked daily bus trips.

FIGURE 1-7
MARTA Rail System and North Line Extension



1.4 OVERVIEW OF NAVIGATOR

This section provides a general description of the capabilities and communication structure of the ITS systems installed in the Atlanta region, including ATMS/ATIS components, APTS components, the Atlanta TIS, and the FHWA FOTs (ADAS and Kiosk). More complete descriptions of the system components are provided in Section 2.1. At the time of this report, there were eight "members" of the regional ATMS—GDOT, MARTA, the Counties of DeKalb, Cobb, Clayton, Gwinnett, and Fulton, and the City of Atlanta. The ATMS is designed to expand to a state-wide interconnected system with many additional "members."

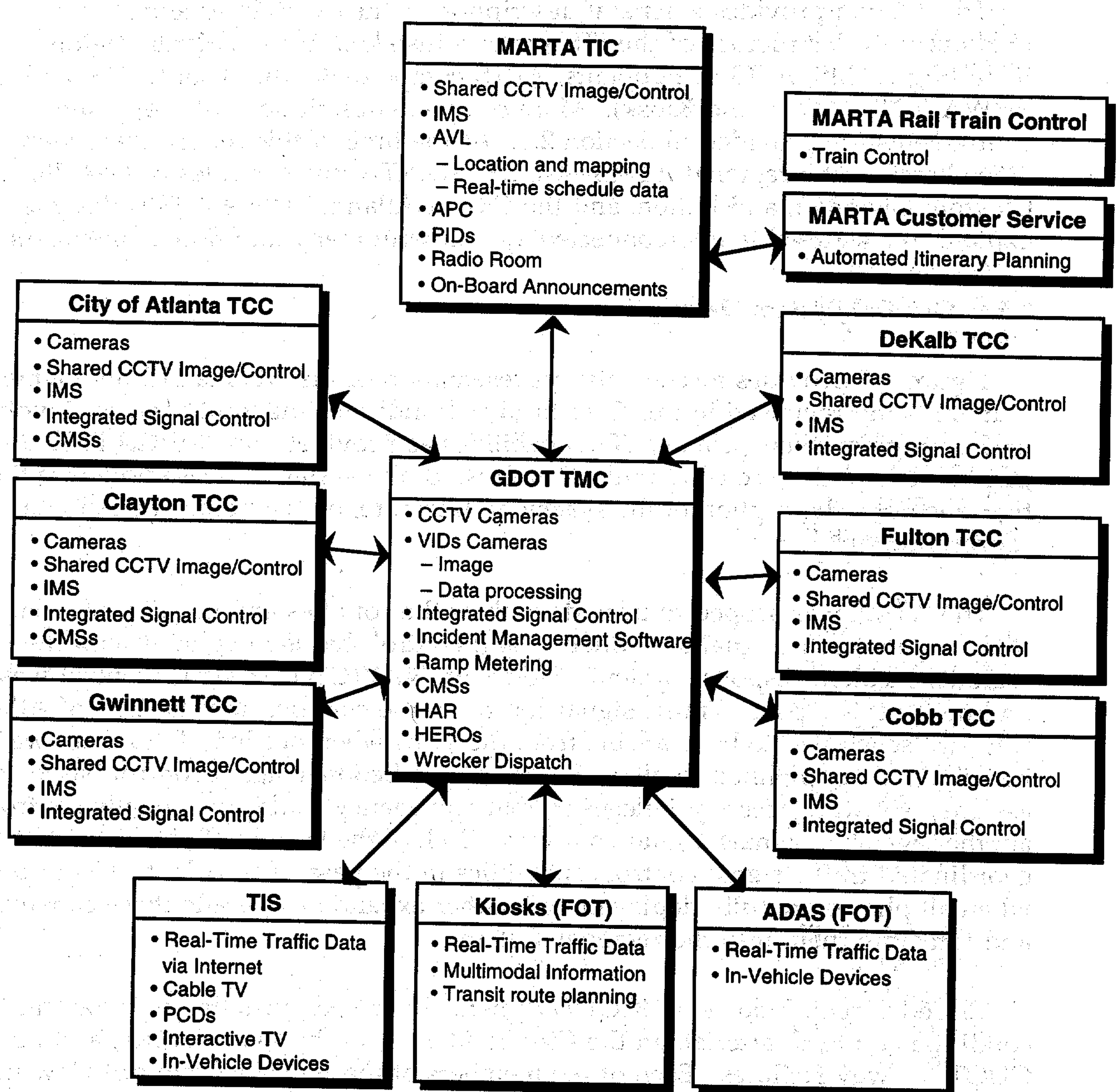
1.4.1 General System Description

Figure 1-8 provides a schematic representation of the Atlanta ITS deployments that are being reviewed in this Case Study. It indicates the local agencies involved in the program, their primary ITS capabilities as provided in NAVIGATOR, and the general data and voice communication flows of the system. Please note that the figure is not a description of the system architecture, but is merely a schematic representation.

The ATMS was scoped to provide each of the counties and the City of Atlanta with remote traffic signal coordination and control that is integrated with the regional incident response system. However, NAVIGATOR signal control was not on line for this report. Traffic signal control at the counties and the City of Atlanta was also scheduled to be available from the TMC when needed. Future software installations are planned to allow for cross-jurisdictional signal control based on assigned software access privileges so that any agency could functionally control another agency's signals if granted access. Each of the local DOTs had remote and coordinated traffic signal control capabilities in the past. The Atlanta ATMS project, when all phases are fully deployed, will either expand or upgrade those capabilities and integrate them into the regional system.

Closed Circuit Television (CCTV) cameras have been installed to view traffic conditions on local arterials in the City of Atlanta, in the five counties, and on GDOT freeway facilities. Each of the members of the ATMS system can view images from any of the cameras in the region, regardless of who "owns" the camera. They also may use the pan, tilt, and zoom camera functions. However, a control hierarchy has been established whereby the agency that owns the camera has principal control over the camera position, and can override the positioning control of any other agency. Clayton County has installed a passive video feed into the 911 dispatch center adjacent to its TCC. This will allow 911 dispatchers to view on-street traffic conditions, but will not provide access to camera selection or controls.

FIGURE 1-8
NAVIGATOR Regional Schematic



The Changeable Message Signs (CMS) are used primarily to provide drivers with information regarding downstream traffic conditions. CMSs have been installed on GDOT freeways in the five metropolitan counties and on arterials in Clayton County. The City of Atlanta plans to install CMSs on arterials feeding the freeway system.

GDOT has installed Video Image/Detection System (VIDS) cameras to provide automated incident detection, congestion information, and visual confirmation. The system was not fully operational at the time of the Olympic Games. VIDS images were available, but only a limited capability was available for the image processing functions that are part of the incident detection system. The VIDS images are stationary and were available to all members of the regional ATMS at the time of the Olympic Games. The system is now fully functional.

The Atlanta ATMS includes an integrated Incident Management System (IMS) that is accessible by all agencies in the system. Any agency may input an incident into the system as a means of communicating the incident information to the ATMS members. The software is programmed to provide proposed incident response plans if a pre-programmed plan exists for the incident. Currently, only on-freeway incident response plans exist. The TMC operators implement the plan recommendations or other responses if needed. Incidents can be input by any of the agencies in the ATMS to provide information to assist in regional transportation management. In the future, response plans may be developed for off-freeway incidents. The complete integrated ATMS will be capable of diverting traffic from congested areas onto uncongested facilities via CMSs and Highway Advisory Radio (HAR) messages, and re-timing traffic signals affected by the diversion or congestion. The ATMS software capability currently does not exist to re-time signals as part of a diversion plan and therefore interagency agreements to implement this function have not been pursued further.

Freeway ramp metering was introduced in the Atlanta region in concert with the Atlanta ATMS program. Ramp meters were first installed on the northbound (PM outbound) ramps on I-75 north of the city center between I-285 and the Connector. Additional freeway segments in the Atlanta region, including sections of I-75, I-285, and I-85, have been slated for ramp metering in the near future. Ramps on the Connector are also being considered for metering, but geometric constraints prevent most of these ramps from being metered without major reconstruction. The ramp metering system was not activated during the Olympic games.

Three programs to provide traveler information were conducted in parallel to the Atlanta ATMS, and relied on information provided by the regional ATMS: the Atlanta Driver Advisory System (ADAS) FOT, the Kiosk FOT, and the Traveler Information Showcase (TIS). These projects provided travelers information by way of a variety of media including personal communications devices, the Internet, and in-vehicle devices. ADAS is no longer part of the regional ATMS. Like most FOTs, ADAS was intended as a short-term program developed primarily for the purpose of learning about new ITS technologies and applications. Unlike ADAS, the Kiosk FOT and the TIS have evolved into legacy systems that continue to be operated by GDOT. At present, these two systems are widely used for providing traveler information during day-to-day operations.

The MARTA TIC, also the Bus Communications Center, is the control center for MARTA fixed-route bus service, providing communications, radio dispatching, service level monitoring, incident response, and central coordination for ITS technology. As part of the implementation of the regional ATMS, the MARTA Bus Communications Center was transformed into MARTA TIC with the installation of a direct communications link to the TMC. MARTA TIC is the central facility that deploys ITS technology including the Automatic Vehicle Location (AVL), the Automated Passenger Count System (APC), In-Vehicle Announcements (IVA), and the Passenger Information Devices (PIDs).

MARTA TIC is equipped with special dispatch consoles that allow dispatchers to view AVL-equipped buses as they operate in both revenue and non-revenue service. CCTV cameras can be viewed on a large screen that permits the use of up to nine cameras simultaneously. IMS software is also accessed in this facility from special consoles that allow the user to view camera images and to input transit incident data for transmission to the TMC. Itinerary planning services are centralized in MARTA's Customer Information Center, which is separate from the MARTA TIC. This facility houses several Customer Information operators who answer questions from the public on transit services available from MARTA.

MARTA's TIC, Rail Control, and Customer Information systems are interconnected. Real-time rail and bus information may be sent, via the TMC, to the kiosks and other traveler information devices.

1.5 METHODOLOGY

The methods used to describe the issues and opportunities in Atlanta and to develop recommendations are described in this section. The methodology is diagrammed in Figure 1-9.

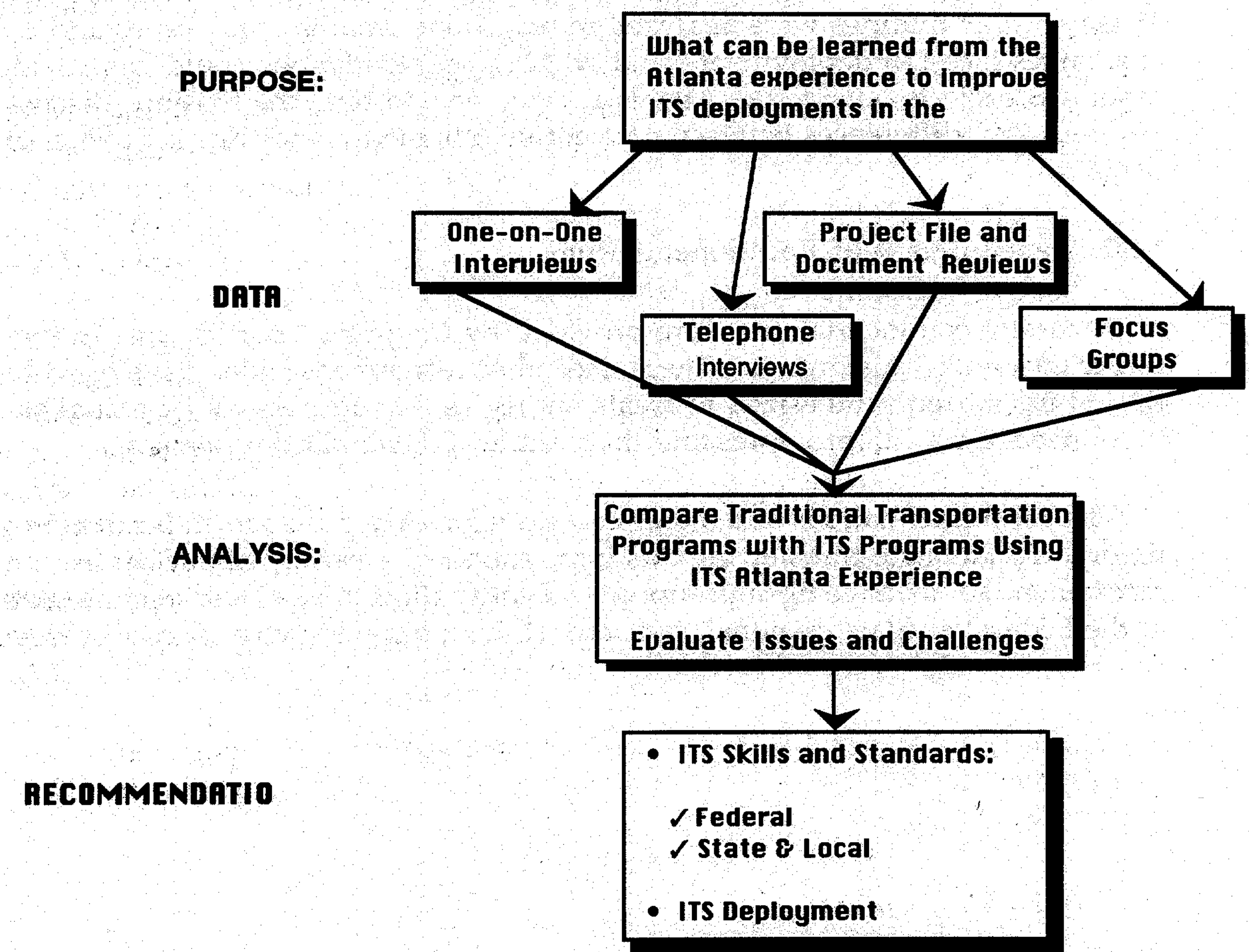
1.5.1 Information Gathered and Findings

Information was gathered from the following sources:

- Project files including correspondence, contracts, weekly reports, and design documents
- One-on-one structured interviews with more than 30 agency and contractor personnel

- Telephone interviews and informal conversations
- Focus Groups including all agencies involved

FIGURE 1-9
Case Study Methodology



The information was reviewed and analyzed to determine what issues arose that threatened the project's success, how those issues were or might be addressed, and which process or concepts contributed to meeting the project goals. The principal topic areas covered in this review include:

- Programmatic—ITS project funding, contractual issues, and project management and accountability
- Institutional—Interagency and intra-agency relations and coordination, and regulatory issues

Technical—Issues related to selecting and specifying hardware, software, and infrastructure

There are interactions between these three main issue areas. For example, a regulatory issue may affect the technical system selected.

The findings in the report relate to specific events found in the Atlanta region. These specific findings were analyzed to determine what general issues and challenges face ITS deployments, and what recommendations could be provided to other ITS projects outside the Atlanta region. In addition, the findings discuss the parallels and differences between conventional highway and transit projects and ITS projects.

1.5.2 Development of Recommendations

Several recommendations were provided by the project participants in the interviews and focus groups. These and other recommendations developed by BA&H have been synthesized to create strategies that address fundamental skill areas needed for ITS programs and the need for ITS standard processes.

The recommendations and suggested strategies are provided in Section 5 of this report. To facilitate transferring this information to a variety of audiences, the recommendations have been grouped to identify those that would best be pursued at the Federal or State, regional, and local (transit provider, city, or county) levels.

2.0 DESCRIPTION OF ITS DEPLOYMENTS AND INFRASTRUCTURE

A variety of ATMS, ATIS, APTS, and infrastructure improvements were installed in preparation for the 1996 Summer Olympic Games. Section 2.1 discusses the ITS components and Section 2.2 details other transportation and infrastructure improvements.

2.1 ITS COMPONENTS

The Olympic and Paralympic Games served as a focus for the deployment of ITS in Atlanta, including both highway and transit components. This section describes the Atlanta Regional ATMS and the Atlanta TIS (an ATIS project). The ATMS/ ATIS components—with links between eight agencies (each with its own control center), and including freeway, surface street, and transit operations—represent possibly the most complex and comprehensive ITS deployment yet attempted in the United States. GDOT has developed a plan for the strategic deployment of ITS throughout the State. The ITS improvements implemented by GDOT before the Olympic Games comprise Phase I of the envisioned statewide ATMS system.

The regional ATMS system installed prior to the Olympic Games has 101.43 km of fiber optic backbone, as shown in Figure 2-1, plus 193.20 km of refreshed arterial communication backbone (primarily copper with a small percentage of fiber optic). These link the GDOT TMC to the MARTA TIC and TCCs in the City of Atlanta and the five surrounding counties of Clayton, Cobb, DeKalb, Fulton, and Gwinnett.

Video surveillance of the freeway network is provided by 89 closed circuit television (CCTV) cameras (22 of which are slowscan), and 319 VIDS cameras installed on freeways and freeway ramps, as shown in Figure 2-2. VIDS was intended to provide traffic speed, volume, and lane occupancy information, but was not fully operational and did not provide any real-time traffic data during the games. Nonetheless, the VIDS cameras did provide additional video surveillance capability. The majority of the freeway video surveillance was concentrated on I-75 and I-85, mostly within the I-285 perimeter. To a much lesser extent, freeway video surveillance coverage is available on I-20, on the I-285 perimeter, and on I-75 and I-85 outside the perimeter. Additionally, 51 radar detection sites collected speed data from locations on I-20 and the I-285 perimeter to supplement the video surveillance capabilities.

FIGURE 2-1
Communications Trunk, Control Centers, and Highway Advisory Radio

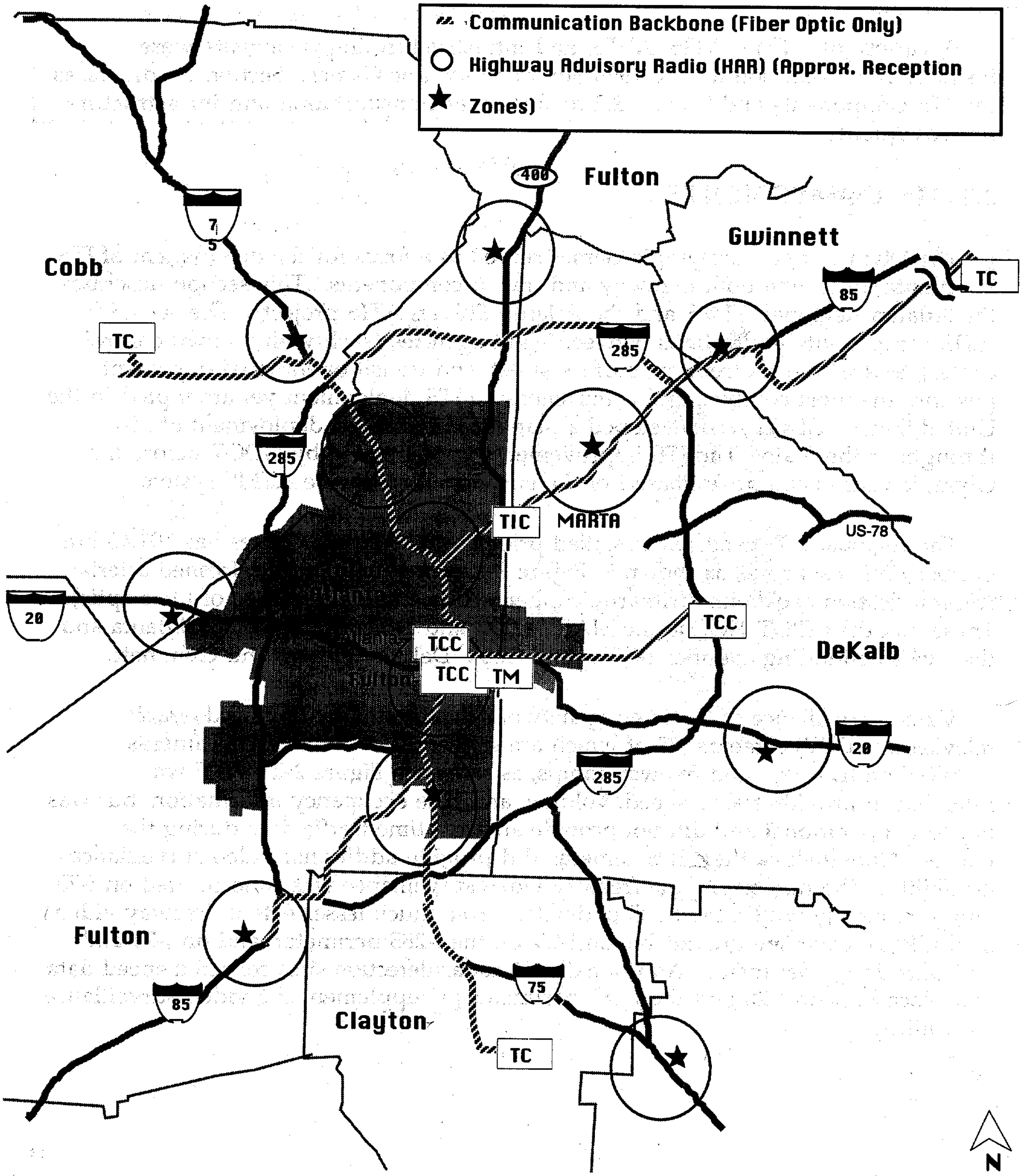
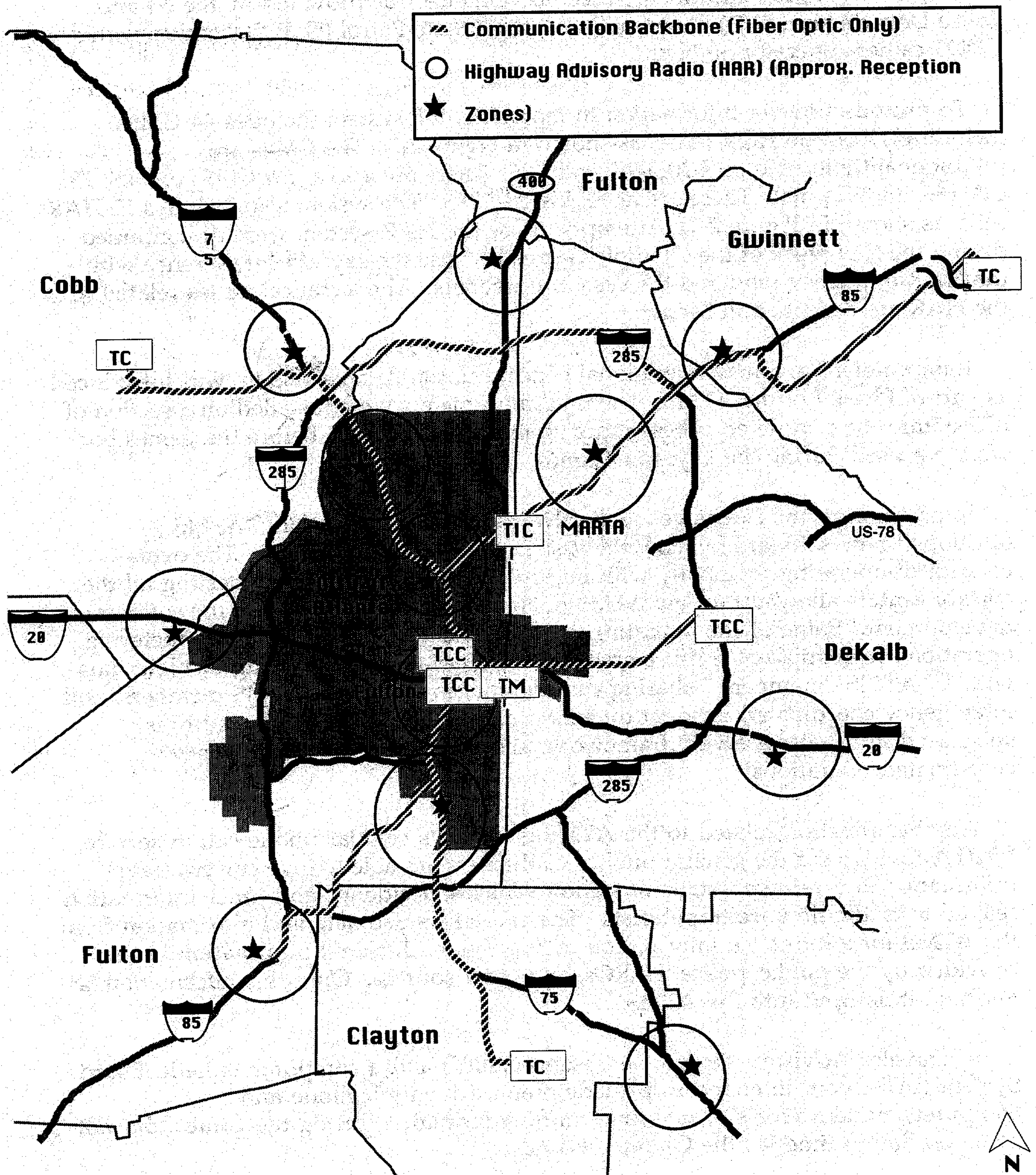


FIGURE 2-2
Freeway Video Surveillance



Twenty CCTV cameras were installed on the City of Atlanta arterials at the start of the games, and an additional 37 CCTV cameras are planned. Two cameras were installed on DeKalb County arterials, and 10 cameras on Gwinnett County arterials. During the Olympics, additional video surveillance was provided by the Atlanta Police Department (APD) blimp, and a Georgia State Patrol (GSP) helicopter with a GDOT camera operator on board.

To provide traveler information to motorists, the system includes 44 CMSs including 17 on the HOV lanes, as shown in Figure 2-3. The CMSs are predominantly located on I-20, I-75, and I-85. There are also a few CMSs on U.S.-78, GA-166, and GA-400. There are no CMSs on I-285. The system also includes 12 HAR cells, as shown in Figure 2-1. Attempts to use the HAR system were discontinued during the first week of the Olympic Games because the skyway interference with the HAR frequency rendered the system unreliable. The technical issues related to the HAR are described in Section 4.

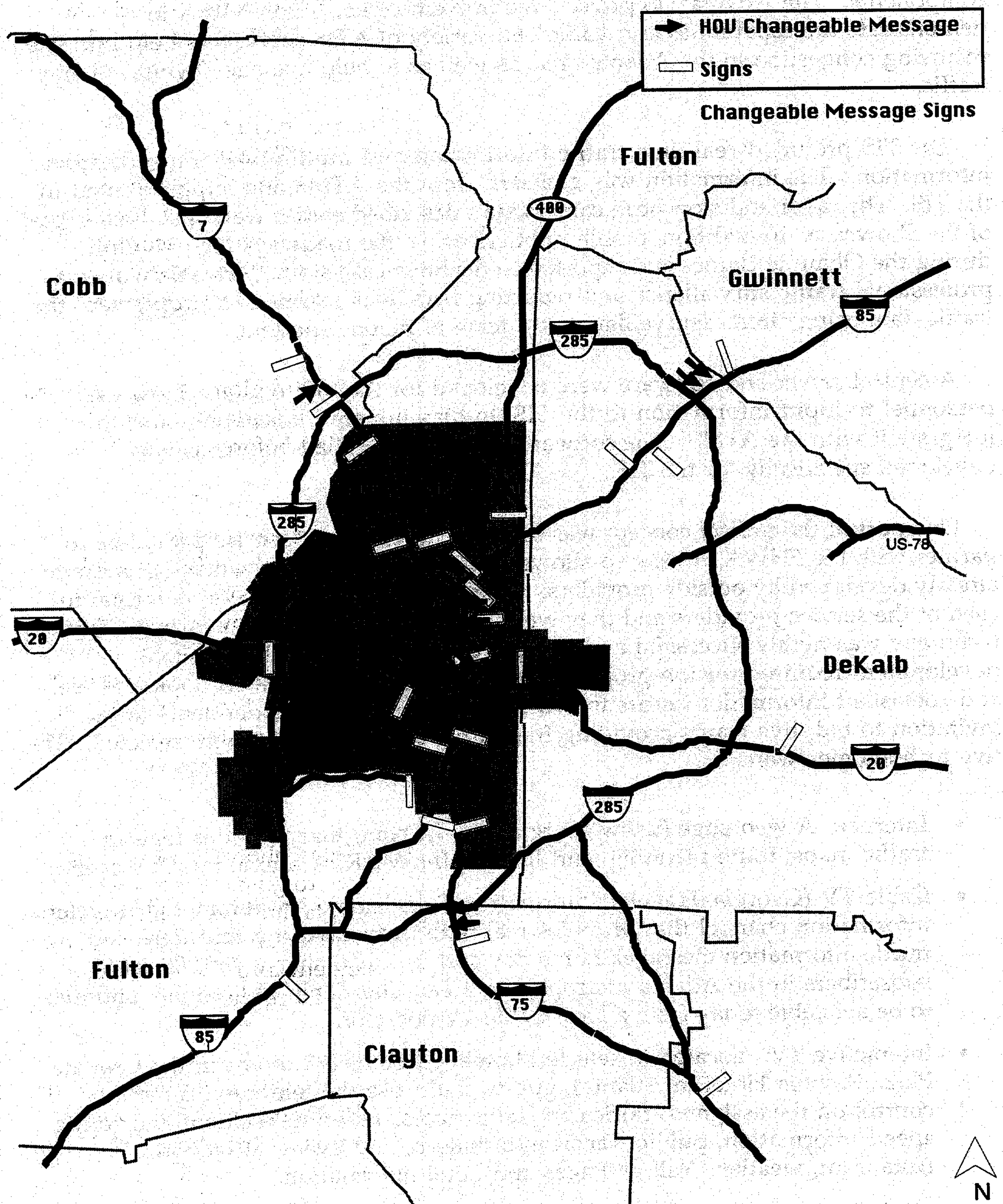
Ramp metering, a new operational concept in the Atlanta region, was introduced as part of Phase I of the ATMS. The first ramp meters were installed on a section of I-75 within the perimeter. These ramp meters were installed before the games but were not used during the Olympic Games.

In addition to the extensive ITS hardware installed, the Atlanta ATMS developed new software to allow the system to operate as planned. The overall concept of operating regionally with multiple agencies and interconnecting all the control centers allowed for new ATMS operating concepts and drove the software development. Some of the operating concepts include integrating ramp metering operations with adjacent traffic signal control, sharing data including incident data with all ATMS "members," sharing camera images among all ATMS members, and interagency coordinated incident diversion plans. The ATMS architecture is structured in a "client-server" framework, allowing for ease of interagency coordinated operations.

Another function related to the ATMS is GDOT's cellular phone call-in service, *DOT, provided for the general public. Call-takers are able to give current travel information and receive details of stalled vehicles, accidents, and other information related to traffic flow from motorists. The call-takers use data and information from the ATMS for a lot of the information they provide. Incident information is also provided by the public, police, HEROs, and other sources. Once this information is verified, it is input into the ATMS.

A Traveler Advisory Telephone System (TATS) and a computer Bulletin Board System (BBS), both intended to provide menu-driven telephone and computer/modem access to real-time traffic information during the games, did not come on line in time for the Olympic Games.

FIGURE 2-3
Freeway Changeable Message Signs



2.1.1 The Atlanta Traveler Information Showcase (TIS)

An important feature of the regional ATMS is the link to the Atlanta TIS components. The Atlanta TIS project was implemented by the FHWA to demonstrate the capabilities and value of a variety of ATIS services to help mitigate recurring congestion in the Atlanta area, as well as to help manage Olympic Games traffic.

The TIS provided real-time traffic information and multimodal transportation information. The information was gathered from the ATMS and supplemented by the TIS. The radar and slow-scan camera sites described earlier were installed as part of the Showcase. In addition, mobile spotters drove the roadways for 16 h daily during the Olympic Games and reported to the Showcase staff. MetroNetworks, a professional traffic surveillance and reporting firm, was retained to supplement the traffic data using aircraft surveillance and team of mobile spotters.

A central server and software were developed for the TIS to allow Showcase personnel to input information to the TIS, to disseminate information, and to integrate it with the ATMS. The software necessary for these functions was developed specifically for the TIS.

One part of the project concept was to invite independent service providers to partner with the FHWA. Doing so allowed the project to take advantage of systems already developed by outside providers. Data was provided in the same format to each of the service providers and they were required to adapt to this format. This technique was highly successful and helped reduce the amount of software development required for the project. This also provided a common look and feel and consistent information across the various devices. Of 41 respondents to the invitation to bid, five teams providing five different technologies were selected. The five technologies were:

- Internet: A web page (www.georgia-traveler.com) that provides real-time traffic maps, route planning, and links to the MARTA public transit system.
- Cable TV (Georgia Traveler Information Television): An automated traveler information channel that provides real-time traffic and incident data and traffic information messages 24 h a day and was available to 750,000 cable subscribers in the Atlanta metropolitan area. The Cable TV system continues to be available today from a local Cable TV operator.
- Interactive TV: Located in selected hotel bedrooms (85 rooms in the Crowne Plaza Ravinia Hotel in Atlanta), guests could use the television remote control on the assigned traffic channel to access real-time incident and traffic speed information, public transit information, and event, attraction, restaurant, weather, Yellow Pages and hotel information.

- In-vehicle navigation systems: An in-dash unit, which provided maps showing turn-by turn directions with real-time traffic, speed, and incident data was distributed to 96 drivers.
- Personal communications devices: Small, hand-held computers were linked to the independent service providers' central computer system, using wireless communications. The devices provided real-time incident, traffic speed data, and transit information. Two hundred and twenty-two devices were distributed for use during the Olympic Games.

The TIS continues to be used to provide traveler information in the Atlanta region. All of the system equipment, except the personal communications devices, were transferred to GDOT. The capabilities and types of information disseminated via the TIS continue to expand as the ATMS and the service providers increase their capabilities. For example, the Internet site now provides access to over 60 live video shots of freeway traffic from the ATMS cameras.

2.1.2 Field Operational Tests (FOTs)

Two FOTs were initiated for the games. These were the Atlanta Kiosk and Atlanta Driver Advisory System (ADAS). Both projects provided additional means to disseminate traffic information.

- **Atlanta Kiosk FOT**—The kiosk system provides information from several sources to travelers in Georgia using a network of 130 kiosks located in the Atlanta metropolitan area and statewide. The types of information provided include real-time traffic conditions, route planning, transit services, MARTA itinerary information, air transportation information, rideshare information, Olympic Games and special event information, travel and tourism information, and weather information. Each kiosk is a self-contained unit containing a processor, monitor, printer, and communications interface. Travelers access the information using a touch screen. Display menus allow travelers to work through a hierarchy of information types.
- **Atlanta Driver Advisory System (ADAS) FOT**—ADAS was planned to provide information to as many as 100 Federal Express and 100 GDOT vehicles within the metropolitan area of Atlanta. A major part of the information provided to the vehicles was generated by the ATMS. The interfaces between the ATMS and the vehicles was accomplished with a Subcarrier Traffic Information Channel (STIC), Wide-Area 220 megahertz (MHz) channels, and Local-Area 220 MHz channels. Much was accomplished to establish the link between the ATMS and the ADAS system prior to the Olympic Games. However, for a variety of reasons, ADAS was not operational during the games. The ADAS test operational period occurred in late 1996.

2.1.3 APTS Components

Prior to the deployment of ATMS, MARTA TIC (formerly the radio room) was responsible for bus scheduling and transit incident management functions. Every bus in the MARTA fleet was fitted with radio communications to support these functions. (Unlike the TMC, calls from the public were not handled by MARTA TIC, but by MARTA's Customer Information department.) The MARTA TIC is now the control center for the APTS.

The APTS project deployed during the Games, called ITS MARTA '96, featured the following components:

- **ATMS**—The MARTA portion of the ATMS was enabled by a fiber optic connection between MARTA Headquarters Building and the GDOT TMC. This fiber optic link allows MARTA to access other agencies' CCTV cameras and the IMS, and function like any other TCC in the system.
- **Automatic Vehicle Location (AVL)**—This system locates buses in real-time and displays their position on a computerized geographic information system (GIS) map. The GIS is linked to satellite Global Positioning System (GPS) technology used for the AVL system. Augmenting the satellite reception is a differential satellite receiving location at the MARTA TIC.

  MARTA equipped 250 buses in the regular fleet with AVL units. Route 5 was designated as the primary recipient of AVL-equipped buses because it operated from Lindbergh Station, close to MARTA headquarters. This facilitated system monitoring. The AVL system became operational and available to MARTA approximately 3 weeks before the games began. The AVL system has three primary functions as a transit surveillance component:

  1. To locate the position of buses as they are operating in revenue or non-revenue service. Bus dispatchers can use this information to automatically evaluate route schedule adherence and to assist bus operators with directions or reroutes due to traffic congestion or road emergencies. The route schedule adherence component was not operational during the games.
  2. To communicate mechanical problems or failures detected through equipment alarms that are automatically activated by sensors on the bus.
  3. To assist a bus operator during times of emergency. On each AVL-equipped bus is a covert microphone that allows the dispatchers to listen in on any activities on the bus, if activated by a bus operator.
- **ATIS/Itinerary Planning**—This component uses a computer system that merges the GIS system with the bus and rail schedules to develop individualized trip itineraries that respond to customer queries. This

component is more commonly known as the Passenger Routing and Information System (PARIS).

Customer information telephones were also located within rail stations to connect customers with MARTA information operators who have access to the automated trip itinerary planning capability of the ATIS. This information is available in English, French, Spanish, German, and Japanese.

- **In-vehicle Announcements**—This component uses the AVL system to provide audio and visual announcements of bus stops along their assigned routes within the equipped buses. This component was installed on 100 of the 250 AVL-equipped buses.
- **Automated Passenger Counters (APC)**—This is an additional component of the AVL system and was planned to be installed in 15 of the 100 buses with the in-vehicle announcement component. Installing the APC on AVL-equipped buses provides the mechanism for reporting current passenger count information to the MARTA TIC by radio communications. During the Olympic and Paralympic Games the APC system was installed only on 3 of the planned 15 AVL-equipped vehicles. This installation was completed soon after the Games and has been fully operational since October 1996.
- **Passenger Information Devices**—Two types of Passenger Information Devices (PID) were deployed: rail station monitors, and bus-stop light emitting diode (LED) signs. Nine 27-in. monitors were located in the higher volume MARTA rail stations with bus transfer facilities, to provide passenger information. These monitors display the scheduled departure times and the real-time status of connecting bus services. These monitors were not operational during the games except to occasionally display schedule (not real-time) information.

  Six LED signs were located at bus stops and bus shelters to similarly display the scheduled departure times and the real-time status of buses operating along that route. The LED signs were located at bus stops serving only one or two routes. They are not designed to provide information for more than two routes on each sign. These signs were also functional during the games, but not to provide real-time information.
- **Smartcard Fare Implementation**—This was a pilot test of smartcard technology, sponsored by VISA and Nations Bank, to examine the feasibility of multi-use smartcards for all types of retail applications including transit. Stored-value card reading devices were located at fare gates at selected MARTA rail stations.
- **MARTA Rail Train Control System**—MARTA recently replaced its train control system that had been in place since the late 1970s. The train control system was fully implemented, tested, and operational prior to the games. It was necessary to have this new system in place to support the opening of the North Line Extension. The previous train control system would not have

been able to accommodate this expansion of the rail network. The entire rail system is centrally controlled.

Staff view rail system conditions on video monitors and large mosaic display boards in the central operating room, monitoring and controlling the progress of trains along the North/South and East/West Lines. The central operating room is configured with two separate computer systems:

- The Train Control Computer System monitors each train along the guideway and provides real-time information to the staff controllers regarding train location and operating status, e.g., vehicle speed, doors opened/closed. The system is responsible for ensuring safe flow of trains through each of the stations while maintaining the required distance from other trains along the same route. In addition, the system can automatically shut down the operation of a train if it is determined to be at an unsafe distance from other trains.
- The Supervisory and Control Computer System monitors electrical power to the guideway and trains and provides the controllers with several safety functions to identify power surges, fires, or track malfunctions.

2.2 OTHER TRANSPORTATION AND INFRASTRUCTURE PROGRAMS

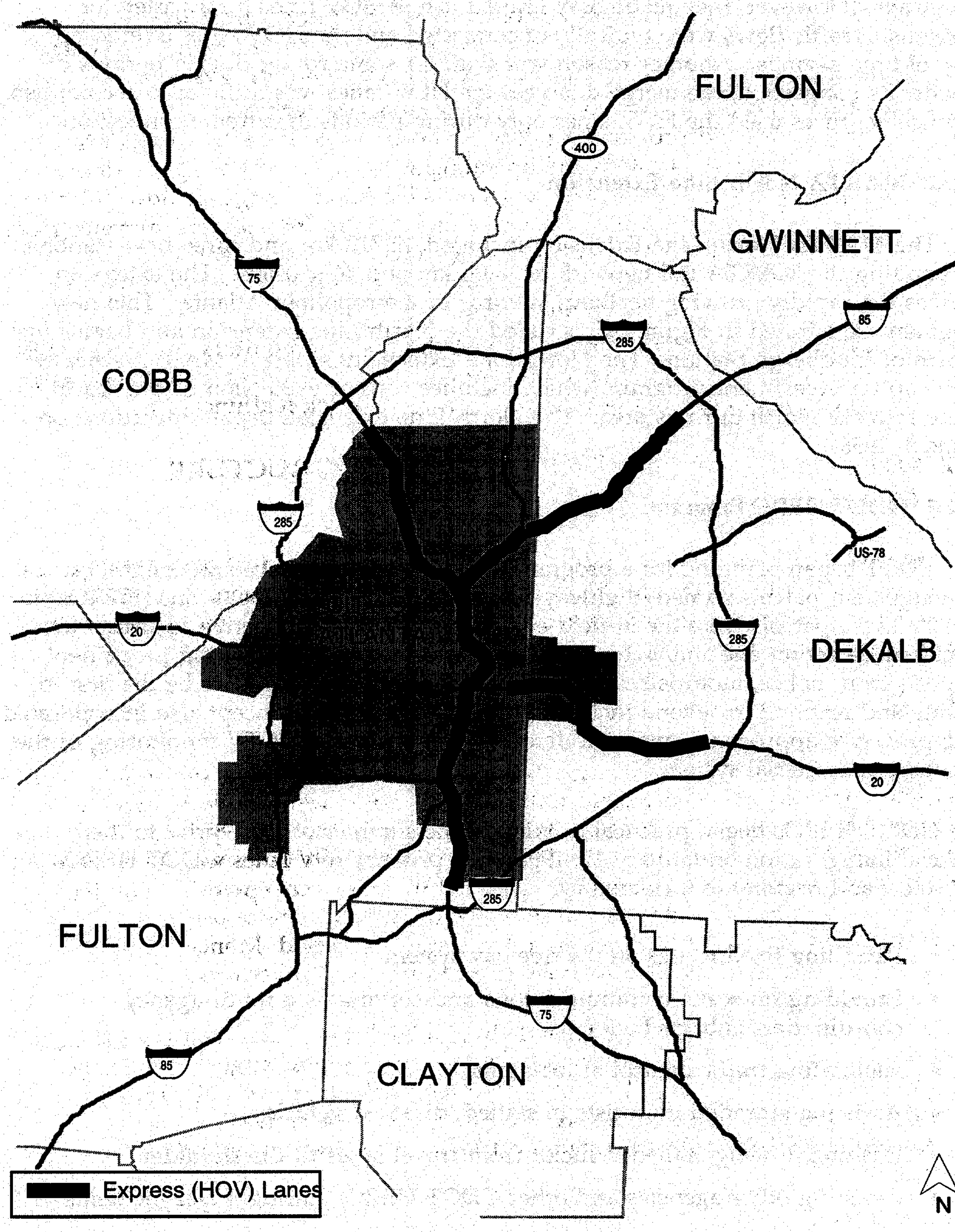
Two major infrastructure components were also deployed just before the games. These were the HOV lanes and the MARTA North Line Extension. In addition, several other programs, some targeted exclusively to Olympic Games transportation, were under way concurrently with the ATMS development and deployment.

2.2.1 HOV Lanes

A network of HOV lanes was deployed in Atlanta to encourage car-pooling and promote transit use. Seventy-eight miles of HOV lanes were implemented on freeways within the I-285 Perimeter, covering all of I-75, most of I-85, and I-20 east of the I-75/I-85 Connector (Figure 2-4). The I-75 and I-85 HOV lanes were opened in June 1996 and operate 24 h per day. The I-20 HOV lanes were opened in late 1994 and operate westbound (inbound) during the morning commute period and eastbound (outbound) during the afternoon commute period, Monday through Friday. The HOV lanes on I-20 are open to all traffic at all other times.

Only six freeway interchanges have dedicated HOV lane entry/exit ramps. All but one of these are limited by direction, i.e., the three interchanges north of the CBD have northbound on-ramps and southbound off-ramps, with the reverse situation for the two interchanges south of the CBD. (The fully directional interchange is on I-75 at Aviation Boulevard, which is near the airport to the south of the city.)

FIGURE 2-4
Express (HOV) Lane System



The HOV lanes are available to vehicles with two or more occupants and to motorcycles. Although regular scheduled MARTA bus services rarely use the freeways, buses used for Olympic and Paralympic Games operations made use of freeways. However, they made only limited use of HOV lanes for a variety of reasons. Traffic flows were typically uncongested and the HOV lanes offered no travel time savings. Another reason was that, for some routes during periods of moderate congestion, the merge to access the HOV lanes was difficult to accomplish. Typically, buses used the HOV lanes only during periods of extreme congestion.

2.2.2 MARTA North Line Extension

The MARTA North Line Extension included 12.719 km and three new stations, expanding the MARTA rail network to 74.06 km and 36 stations. The extension serves the rapidly growing northern suburbs of metropolitan Atlanta. This new segment, illustrated in Figure 2-5, is called the North Line Extension and begins just north of Lindbergh Station. The North Line Extension is part of MARTA's heavy rail capital investment program, which includes further expansion of the North Line into the North Springs area. The North Line extension began operations on June 8, 1996.

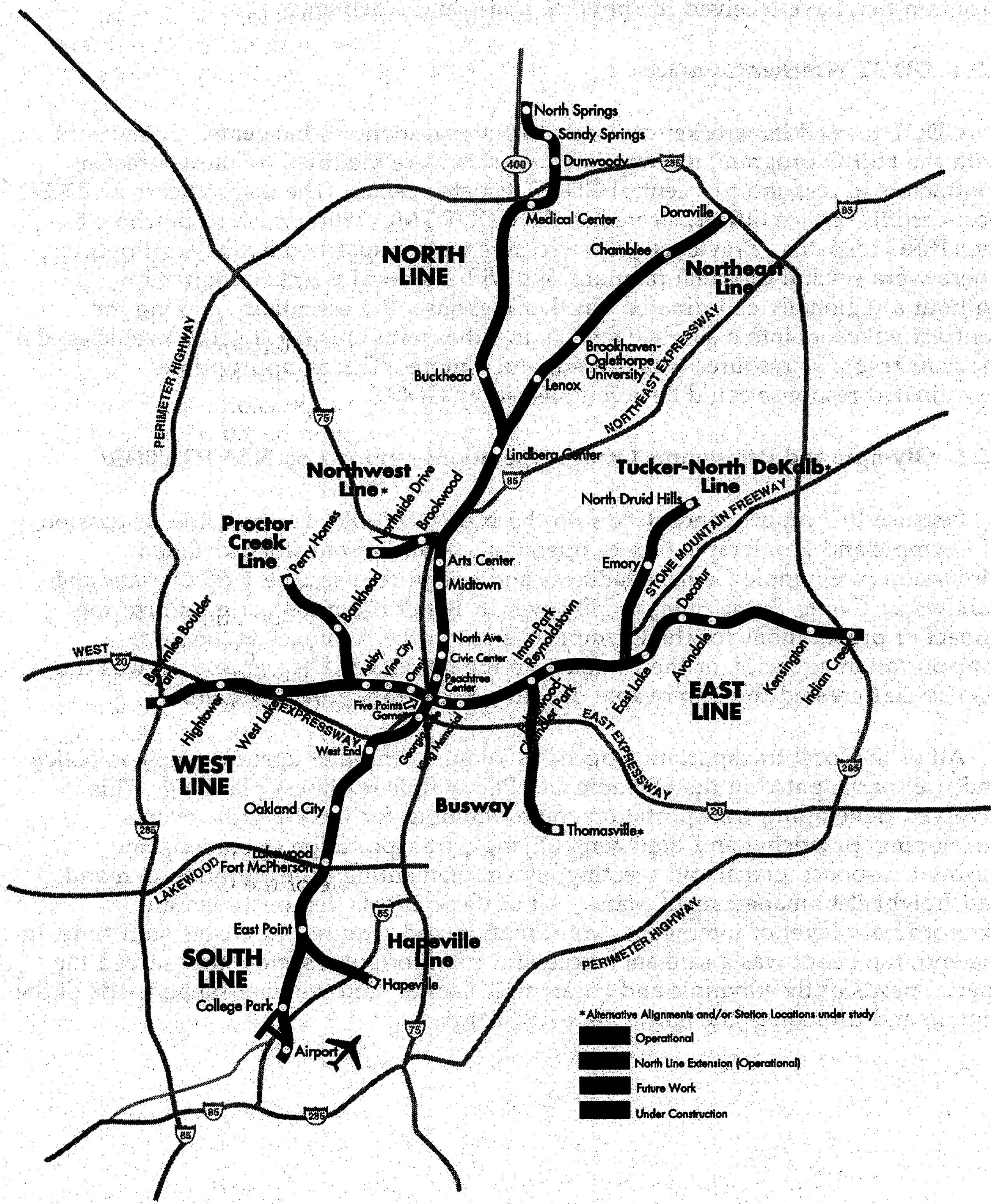
2.2.3 GDOT HERO Program

GDOT began planning for a program to deploy safety service and congestion management patrols named Highway Emergency Response Operations (HEROs) in 1992. These patrols were the in-field evidence of GDOT's pro-active approach to incident detection and management. Rather than simply responding to incident reports from police, motorists, and others, HEROs allowed GDOT to be the first to locate and respond to several incidents. The GDOT ATMS concept also incorporated the proactive approach to incident detection via VIDS and CCTV monitoring of the freeway and arterial system.

GDOT HEROs began practical training in the summer of 1995, prior to their official inauguration on January 17, 1996. The primary role of the GDOT HEROs is to detect and respond to incidents by:

- Patrolling fixed routes on the freeway system
- Providing on-scene communications and serving as a multi-agency coordination hub for incidents
- Facilitating traffic control at incidents
- Assisting stranded motorists in stalled/disabled vehicles
- Pushing/towing stalled vehicles from travel lanes to the shoulder
- Assisting other agencies and other GDOT HEROs during major incidents

FIGURE 2-5
Existing and Planned MARTA Rail System and North Line Extension



GDOT HEROs are dispatched by a certified GDOT officer upon request from TMC operators or supervisors to assist in incident response. The GDOT HEROs are a highly visible, highly successful component of the GDOT incident management program that have received the public's praise and acceptance.

2.2.4 GDOT Wrecker Contracts

GDOT revised its wrecker contracts to better respond to incidents. Concurrent with the HERO program, the wrecker contracts were modified to allow wrecker contractors to respond to a central GDOT dispatch center. The dispatcher is a GDOT post-certified police officer, located in the GDOT TMC, who is also responsible for the HERO dispatch. Previously, the wreckers were dispatched by the local police. There were several dispatch relationships with the local wrecker contractors, without a regionally coordinated wrecker response. By essentially pooling the contract wreckers into a single dispatch, together with the GDOT HERO vehicles, the incident response resource was pooled, and a more efficient, appropriate, coordinated response could be accomplished by GDOT.

2.2.5 Olympic and Paralympic Games Operations—Impact on NAVIGATOR

Because this report concentrates on the NAVIGATOR elements, the discussion of Olympic and Paralympic Games operations is minimized (for a detailed discussion of Olympic Games readiness and operations, see the *1996 Olympic and Paralympic Games Event Study*). However, it is not the intent to minimize the impact of preparations for the Olympic Games on the resources at the local transportation agencies, or their impact on the NAVIGATOR systems. It was the Games that created the immovable deadline, accelerating deployment.

All of the local transportation agencies (along with other agencies such as police and fire) participated in the Olympic and Paralympic readiness planning. This involved developing transportation route planning for the Olympic events; developing, practicing and deploying Olympic transportation operations and incident response plans; and creating and implementing transportation demand and freight fleet management plans. All of these efforts demonstrated an extraordinary level of interagency coordination and required extensive staff time. In the end, the result was a safe and successful transportation system that served the special needs of the Olympic and Paralympic Games, and the long-range needs of the region, and ultimately the entire State of Georgia.

3.0 ATLANTA CASE STUDY TIMELINE

The development of the NAVIGATOR program was closely intertwined with the 1996 Olympic Games. However, deployment of ITS technologies had been under consideration within the Atlanta metropolitan area long before the games were awarded to Atlanta. To set the historical context for the Case Study, some of the key events and milestones leading up to the games are presented in Figure 3-1 in a timeline format. The timeline relates the activities of the different agencies and organizations involved in the development of NAVIGATOR, and in the transportation planning for the games. The timeline is not intended as a comprehensive record of events. It is meant to illustrate the sequence of events that transpired in deploying the regional NAVIGATOR program.

In addition to Figure 3-1, the events depicted in the timeline are described more fully in a series of "time blocks" covering the period between 1977 and 1996:

- 1977 to 1992—The beginnings of NAVIGATOR
- 1993 to 1994—The impact of the Olympic Games unfolds
- 1995—The construction "crunch" begins
- 1996 onwards—The Olympic experience and the future of NAVIGATOR.

Each event in Figure 3-1 is cross-referenced to the following text.

3.1 1977 TO 1992—THE BEGINNINGS OF NAVIGATOR

The earliest reference to advanced traffic surveillance and control technologies (1)
has been traced back to the *Regional Transportation Plan for 1978-2000*, published by the Atlanta Regional Commission (ARC) in 1977. Policy IV identified the need to "Optimize traffic flow on existing freeways through cooperative surveillance programs, freeway ramp metering, and other control mechanisms." Although the document identified the vision and need to implement ITS, no specific program was then identified to bring that vision to fruition.

Agencies other than ARC operated the transportation infrastructure and were (2)
responsible for putting forward ITS projects. Transportation system improvements through the 1980s took the more conventional form of a major overhaul and widening of the regional freeway network dubbed "Freeing the Freeways." From
the late 1970s through 1984, the initial MARTA rapid transit system was constructed (3)
with revenue service to Brookhaven Station on the Northeast Line, Lakewood
Station on the South Line, Hightower Station on the West Line, and Avondale (4)
Station on the East Line. The rapid transit system was further extended to Hartsfield International Airport in 1988, completing the South Line.

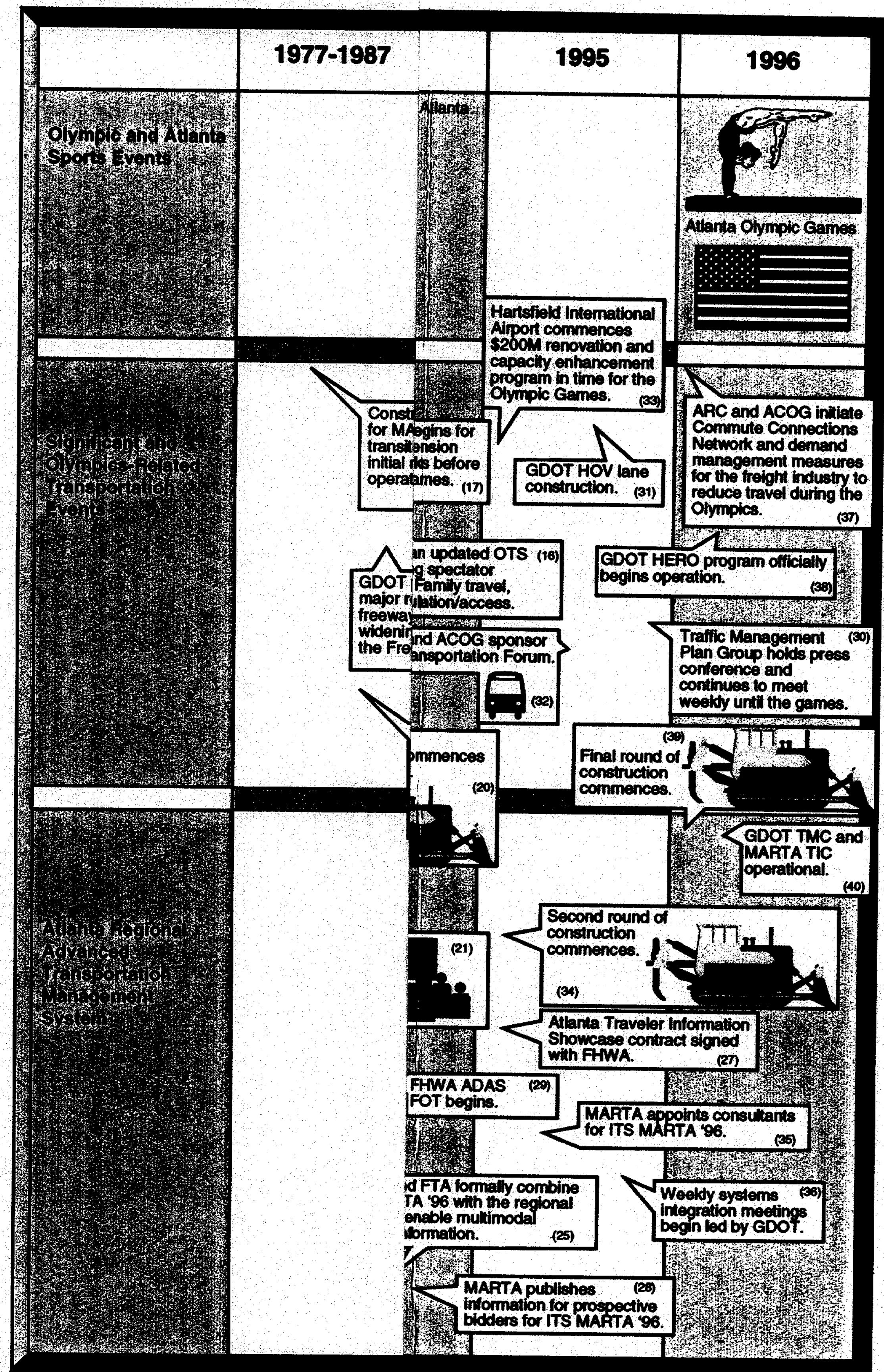


FIGURE 3-1
Atlanta Case Study Timeline

[illegible]

In November 1990, at the request of DeKalb County, MARTA initiated a study of extending the rapid transit system into Stone Mountain Park, east of Atlanta. Stone Mountain Park would be a venue for the Olympic Games, although the study concluded the extension would not be feasible. (5)

The City of Atlanta began a study in 1987 to determine the best means to upgrade its outdated traffic signal systems. The study included an expert panel of traffic operations engineers from throughout the United States, noted for their ground-breaking innovations in signal control. In 1989, the study was published recommending that the City of Atlanta replace all 800 traffic signal controllers with new Type 170 controllers. All of the signals would be integrated into a central control, replacing the existing traffic control center. The study also recommended that CCTV and VMSs be included as part of an integrated traffic control, incident management, and traveler advisory system for the city alone. The complete system was estimated to cost $40 million, to be implemented over 10 years. The city began actively seeking Federal funds for this project in late 1989. (6)

In mid-1990, ARC, in concert with GDOT, commenced a study of freeway incident management. The study team was charged with recommending short-term, low-cost strategies, focusing primarily on minor incidents, which represented some 80 percent of all incidents. By the time the study team reported in February 1991, it was recognized that the upcoming 1996 Olympic Games heightened the need for mobility with minimum delay. On March 27, 1991, ARC adopted a resolution amending the Regional Transportation Plan 1987-2010 to include freeway incident management as an integral strategy in maximizing freeway efficiency and safety, reducing delay, and managing traffic during special events. (7)

On September 18, 1990, the International Olympic Committee (IOC) announced that the Games of the XXVI Olympiad (the 1996 Centennial Olympic Games), would be held in the City of Atlanta. In its bid to the IOC, the City of Atlanta cited its transportation infrastructure (freeways, MARTA, and Hartsfield International Airport) as a strength. However, there were concerns that more needed to be done to support traffic management during the Olympic Games. The FHWA Georgia Division Administrator recognized that games-related traffic would place heavy demands on the region's highway capacity, considering that an estimated two million visitors were expected and there was no centralized traffic management capability to address these demands. (8)

By coincidence, a major funding opportunity presented itself in the form of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), which became law on November 26, 1991. Earlier versions of ISTEA included $8 million to fund a portion of the City of Atlanta's planned city wide signal system and ATMS needs. With the Games approaching, GDOT and the City agreed that an ATMS system integrating surface street and freeway incident management and traffic control was required. GDOT staff have noted that their vision of the ATMS had always been (9) that of a regional integrated system, capable of connecting multiple transportation agencies and functions. In fact, the complete ATMS is to be a state wide system, with local transportation control centers connected and integrated together via the central TMC. The portion of the ATMS constructed before the Olympic Games is only Phase I of the state wide system.

Ultimately, ISTEA provided $58.1 million to Georgia DOT "for various transportation improvements in connection with the 1996 Olympics, including the City of Atlanta advanced traffic management system (IVHS)." This figure was based on:

- Planning and Design (GDOT) $1.0m
- Computer (TMC) and communication links (GDOT) $7.5m
- Upgrades to 400 traffic signals in the City of Atlanta and 140 other traffic signals within the I-285 Perimeter (GDOT) $41.6m
- City of Atlanta traffic signal control and congestion management project (City of Atlanta) $8.0m

The entire $58.1 million was to be directed to, and administered by, GDOT. The City of Atlanta was an active partner in developing the integrated regional ATMS, in particular its own system needs. However, the city thought that its preexisting commitments, the Olympic Games needs, and the added requirements of designing its own system would strain personnel resources. The city therefore believed GDOT was better prepared to commit personnel to managing the program.

By the end of 1991, funds were available to develop one of the nation's foremost advanced traffic control systems. The Atlanta ATMS was the highest funded ITS deployment under ISTEA.

Responsibility for all aspects relating to the planning and execution of the (10)
Olympic Games, including transportation planning, was vested in a newly formed organization called the Atlanta Committee for the Olympic Games (ACOG). On February 28, 1992, ACOG entered into a contract with ARC to undertake a study of the Olympic Transportation System. ARC established the Olympics Transportation Support Group (OTSG), which was co-chaired by ARC, GDOT, and the City of Atlanta, and included representation by most local transportation agencies. ARC was selected by ACOG in preference over any other local agency because it encompassed all the transportation departments in the 10-county Atlanta region, as well as GDOT, MARTA, and other local organizations. One of ARC's early tasks was the development of inventories of transit facilities, roadway conditions, parking facilities, and lodging facilities. Initial demand estimates rested almost solely upon the Program of Events and anticipated attendance. An extensive modeling effort was initiated, which was refined and updated continuously up until the games.

While ARC was undertaking the Olympic Transportation Study (OTS), GDOT commenced planning activities for Phase I of the regional ATMS. An RFP for Phase I of the regional ATMS was issued by GDOT to 12 prequalified consultants on July 1, 1992. This included a detailed scope of work prepared by GDOT and the City of Atlanta. (11)

FHWA had a formal programmatic oversight role and provided technical support in addition to its formal role. FHWA (jointly with Georgia Tech) organized a 2-day workshop in the summer of 1991, at which industry experts were invited to contribute to the conceptual development of the regional ATMS. (12)

FHWA then sponsored an ITS West Coast tour in February 1992. Representatives of FHWA, GDOT, ARC, and the City of Atlanta visited advanced traffic management deployments in Washington State and California. (13)

The scope of work in the July 1, 1992, RFP for the NAVIGATOR deployments called for "a study and comprehensive plan of implementation for a real time adaptive signal control and ATMS for the Atlanta metropolitan region." Implementation plans were to be consistent with the findings and recommendations of ARC's Olympic Transportation Plan. In addition to the original concept in ISTEA, the system concept had been expanded to include regional integrated arterial and freeway traffic management, multimodal transportation coordination, and multilingual traveler information. Reference was also made to an improved freeway incident management system, and candidate traffic control centers (TCCs) in surrounding counties. The candidate TCCs were selected for their critical role in managing transportation in the Atlanta region. In addition, because ACOG had plans to site Olympic venues either within or near them, the TCCs would be important to event management.

TRW was selected by GDOT in September 1992 to provide consulting services for the regional ATMS, and was under contract on January 22, 1993. Thus, 1992 closed with final negotiations for the consultant contract to design and build the complete regional ATMS. (14)

3.2 1993 TO 1994—THE IMPACT OF THE OLYMPIC GAMES UNFOLDS

ARC presented the initial findings of its OTS study in April 1993. It was apparent that spectator movements were a major challenge, because of the concentration of venues inside the Atlanta city center (Olympic Ring). An analysis was undertaken of traffic movements in a number of locations, selected on the basis of background traffic levels and proximity to venues or other attractions: (15)

- Olympic Stadium/Atlanta-Fulton County Stadium
- Olympic Center
- Downtown Hotel District
- Stone Mountain Park

Even allowing that most spectators would be using transit, other factors including pedestrians, background levels of traffic, and the mobility of residents and businesses remained enormous challenges. ARC concluded there would need to be a significant reduction in work trips through a travel demand management program.

ARC's OTS study was on-going, and an updated OTS plan, addressing spectator travel, Olympic Family travel, and venue circulation/access was published in June 1994. (16)

Construction of the North Line Extension began in 1994 (after a planning process that had commenced in 1988). Revenue service commenced on June 8, 1996, just prior to the Olympic Games. (17)

With TRW's appointment came a new scope of work in the form of a study with 29 deliverables. These deliverables generally followed the same themes as the earlier scope of work in the RFP, but excluded the component related to multimodal transportation coordination. The foremost work item was the construction of the GDOT TMC, which, because it functions as the central hub to connect all ATMS functions and agencies, was essential to the program. While two deliverables in the January 22, 1993, contract scope of work made reference to priorities for the Olympic Games ("Recommendations for Other Regional TCCs" and "Design and Specifications for Advanced Vehicle Identification System"), specific linkage to ARC's OTS planning efforts was not included. (18)

In early April 1993, TRW published a draft ATMS Conceptual Design, which represented the conceptual plan for the system and addressed: (19)

- Future Vision
- Transportation Management Strategies
- Operations Concept
- Hardware/Software Architecture
- Communications Architecture
- Field Equipment Description
- Facility Design and Accommodation

- ATMS Test Program
- Personnel, Operations, and Maintenance
- System Implementation

This Conceptual Design was initially reviewed by GDOT, the City of Atlanta, and FHWA. The Conceptual Design was provided informally to the affected counties at this time, and they officially commented on system concepts in June 1993. An on-going dialogue was maintained between GDOT and MARTA regarding the regional ATMS. However, because MARTA lacked funding at that time, it had no official role in the ATMS design and did not comment on the Conceptual Design. In parallel, Cobb County initiated its own ATMS Conceptual/Functional Design Study, completed in July 1994. While the counties were generally enthusiastic about the ATMS, their enthusiasm was tempered by a lack of available personnel and construction funding, particularly as the onus was placed on the counties to seek funding through ARC in sufficient time to achieve results by December 1995. The ATMS Conceptual Design remained a draft, but was referenced in the ATMS System (functional) Specification published in May 1994. This latter document was not a project deliverable but was an essential step in the process of developing the ATMS.

In addition to the TMC construction, an initial round of construction contracts (20)
were let for City of Atlanta traffic signal upgrades in late 1993. Construction commenced in 1994 and focused on the fiber optic communications trunk, outfitting the Atlanta TCC (excluding hardware and software) and freeway CMSs.

In 1993, ARC/ACOG created five study teams to refine transportation plans for the games, and to provide agencies and businesses the opportunity to review and comment:

- Olympic Ring Venues and Downtown Circulation
- Outlying Venue Circulation
- Transit Operations Planning
- Transportation Demand and Congestion Management
- Data/Model Management and Refinement

To support its freeway incident management initiative, in 1992 ARC established an Incident Management Task Force that included representatives from GDOT, law enforcement (State and local), fire departments, American Automobile Association, trucking associations, local traffic agencies, Georgia Emergency Management Administration (GEMA), and MARTA. Reporting to the Task Force were four Action Teams, which were established March 25, 1993:

- Incident Management Handbook/Laws and Regulations (GDOT lead)
- Contract Wrecker Services/Service Patrols
- Communications
- Public Awareness/Promotional Activities

In June 1993, a fifth committee, the ATMS Coordinators Group, was added at the request of the five counties included in GDOT's ATMS Conceptual Design document, to provide a forum to coordinate regional ATMS planning.

From June 1993, ARC chaired regular ATMS coordination meetings, attended by GDOT, the City of Atlanta, and the counties. This was an informational forum, and had no executive decision-making powers. MARTA participation occurred for the first time in December 1993.

One year after ARC established its Incident Management Task Force and (21)
associated Action Teams, GDOT established an ATMS Steering Committee whose first meeting was held on June 13, 1994, and continued to meet after the Olympic Games concluded. The purpose of this committee is to provide the necessary coordination and oversight of the operational and technical needs of the ATMS. Chaired by GDOT, the ATMS Steering Committee includes representatives from the founding governmental agencies of the system, plus MARTA. Each of these agencies is a voting member of the committee. ARC, FHWA, and FTA sit as advisory members. Seven technical subcommittees were established (inter-jurisdictional agreements; technology review; communications; software; GIS mapping and data; maintenance; and system operations), which report to a Technical Coordinating Committee. The Technical Coordinating Committee reports the activities of the various subcommittees to the Steering Committee. These coordinating activities essentially replaced the ARC Incident Management activities. ARC's focus shifted to forecasting traffic, bus, and pedestrian volumes for the Olympic Games.

It is important to note that the committees organized by ARC, ARC/ACOG, and GDOT had no official ties to one another, although they shared common members.

The extent to which the ATMS concept had evolved since ISTEA is clearly evidenced by the nearly $60 million that GDOT programmed via the normal Federal-aid funding processes. The additional funding was directed primarily to support intersection timing improvements, communications, and field devices installed in the counties and in the City of Atlanta. Some of this additional money was also directed toward freeway CMS.

(22)

In September 1993, FTA headquarters developed a preliminary plan to showcase APTS technologies. Central to this effort was an Automatic Vehicle Location (AVL) system providing real-time bus location information.

In December 1993, FTA requested MARTA to develop a proposal for transit ITS implementation. Once MARTA was brought on board with the regional ATMS concept, it was found that the system would support the provision of real-time transit and rail information to travelers, thus enhancing MARTA's overall mission. After discussions with MARTA later in the year, three functional areas were identified for implementation: (23)

- Bus preemption at traffic signals
- AVL
- Passenger information

In April 1994, FTA requested funding assistance from FHWA for its plans to showcase transit ITS technologies, which had become known as ITS MARTA '96, in Atlanta. Over the course of the summer of 1994, the scope of ITS MARTA '96 expanded to include multilingual passenger information at major boarding points. MARTA information was also incorporated into the Traveler Information Showcase (TIS) and the Atlanta Kiosk FOT. GDOT had assisted MARTA in the development of its program. The cable TV element of ITS MARTA '96 was to be accommodated via the FHWA/GDOT TIS project. The Kiosk FOT that was already under way under GDOT direction was designed to included interactive transit information. GDOT also coordinated with MARTA to ensure that the MARTA TIC would be connected and integrated into the regional ATMS, with similar functionality as the TCCs. Bus preemption at traffic signals within the City of Atlanta was considered but dropped from the Olympic Games plan. This decision came after discovering that the City of Atlanta had no preemption capabilities, current or planned, in its traffic signal system. Providing this capability was considered cost prohibitive. (24)

On August 19, 1994, FHWA and FTA met to formally discuss the integration of ITS MARTA '96 with the regional ATMS to support a multimodal traveler information system. GDOT had maintained informal communications with MARTA prior to this time, keeping it apprised of their potential ATMS capability. Ultimately, this was integrated into the Atlanta ATMS, which provided transit information to kiosks via the Kiosk FOT and to a variety of media deployed by the Atlanta TIS. (25)

The Kiosk FOT was contracted in late 1994 and deployed 130 kiosks statewide. The interactive electronic kiosks provide real-time information on traffic congestion, MARTA schedules, ridesharing, route planning, special events, (26) weather, and more. The kiosks are located in places such as bus and train stations, office buildings, welcome centers, and the Atlanta airport.

The Atlanta TIS was signed in early 1995. The project provided real-time (27)
transportation information to the public through the following media:

- Cable TV
- Interactive cable TV in selected hotel bedrooms
- In-vehicle navigation systems
- Personal communications devices
- Internet

Meanwhile, ITS MARTA '96 concentrated on:

- The AVL component, which would provide fleet management and passenger information
- Passenger Information Devices (PIDs)
- Automated Passenger Counters (APCs)
- Automated transit itinerary planning

MARTA published information for prospective consultants to furnish, install, (28)
and test the ITS MARTA '96 components on September 1, 1994. The purpose of this publication was to gather information from interested bidders to refine the RFP before publishing it for official bid response.

In September 1994, a Scientific Atlanta team finalized the scope of an FHWA (29)
FOT, the ADAS. The ADAS grant had been awarded earlier in 1994, and was intended to provide in-vehicle information using different types of communication methods (FM Subcarriers, STIC, LAT).

3.3 1995—THE CONSTRUCTION "CRUNCH" BEGINS

By early 1995, the need for the five Study Teams created by ARC/ACOG for games transportation planning was largely past (although work continued on modeling of demand estimates, recommendations for a travel demand management program, and an incident management standard operating procedure for the OTS). These teams were replaced by a Traffic Management Plan Group, chaired by the Atlanta Police Department (APD), and included those agencies responsible for implementation of the detailed plans. The group held a joint press
(30)

conference on December 19, 1995, when the first version of the Traffic Management Plan was released. The Traffic Management Plan Group met weekly up until the games.

The demands of planning and preparing for the Olympic Games, outside of the ATMS, placed strains on staff resources. In addition, the time available to complete the system was growing shorter, and all efforts were directed toward construction of (31)
ITS infrastructure, Express (HOV) lanes, and the North Line Extension. The ATMS Steering Committee met approximately quarterly in 1995, compared with monthly in 1994. The technical committees met only occasionally. These committees did not influence day-to-day decision-making, rather, they provided overall direction to support day-to-day decision-making.

In May 1995, FTA, MARTA, and ACOG sponsored the Olympic Transportation (32)
Forum, at which the initial Olympic Transportation Plans were reviewed and critiqued by 75 senior managers of agencies and organizations with special events operations and/or transit maintenance experience. The forum resulted in a series of recommendations to assist the on-going development of the Olympic Transportation System (OTS):

- Develop specifics of the operating plan:
  - Service schedules
  - Maintenance plans
  - Staffing plans
  - Safety and security plans
- Plan for higher ridership from significant interest in the Olympic cultural events and the general interest in the Olympic experience in the downtown Atlanta area
- Increase the number and capacity of the Park & Ride locations
- Schedule staff terminal reserve trains and gap buses at the venues and major Park & Ride locations
- Include an additional, single centralized location in the downtown for return trips to all regional Park & Ride sites as a general collection point
- Design a downtown bus shuttle service appended to the rail system, to lessen the walk distances and accommodate those who could not walk the long distances
- Prepare contingency plans for the potential replacement of rail services with bus services, should the rail system shut down for whatever reason
- Keep the venue operations clear of pedestrian/vehicle conflicts

- Monitor the progress on the bus pledge agreements to accelerate commitments
- Expand/append the MARTA Control Center capability to include the needs of other Olympic Transportation Systems
- Make the MARTA Control Centers (bus and rail, operations, and maintenance) the single transportation point of contact for MARTA, spectator, and Olympic family services
- Emphasize the dispatch and supervisory staffing, and training needs
- Augment MARTA staff with recent retirees, other transit agency staff, recent military retirees, and school bus operators and mechanics
- Staff the downtown rail stations with volunteers, MARTA staff, and security staff for full crowd management

In January 1995, Hartsfield International Airport commenced a $200 million renovation and capacity enhancement program, which was completed in time for the games. (33)

Between February and July, a second round of construction commenced with the letting of nine construction contracts by GDOT, including those that completed the communications trunk, communications connections to TCCs, TCC outfitting, ramp metering, and HAR. (34)

ITS deployments in Atlanta began to expand, in part due to the anticipated capabilities of the ATMS. In 1994, the interactive information kiosk, originally part of the ATMS concept, became a FHWA FOT. Information would be provided to the kiosks via the ATMS, requiring additional coordination. This was the second FHWA FOT in Atlanta, with ADAS being the first. (26)

On April 4, 1995, MARTA submitted a formal grant application for ITS MARTA '96 to the FTA Region 4 office in Atlanta. The estimated project cost was $16.25 million, of which 80 percent would be Federal funding. The program included a Base System, consisting of a geographic information system, trip itinerary planning system, and integration with the ATMS; Real-Time Information System, consisting of an AVL system, PIDs, in-vehicle stop announcements and signs, and APCs; and Grant Administration, Engineering and Design Review, and Project Management, which was contracted to an outside consultant.

By early May, MARTA signed consultant contracts for the Base System and the Real-Time Information System. PB/Tudor, MARTA's in-house support contractor, was appointed to undertake the Project Management role. (35)

The Atlanta TIS was signed in early 1995. The project provided real-time transportation information to the public through the following media: (27)

- Cable TV
- Interactive cable TV in selected hotel bedrooms
- In-vehicle navigation systems
- Personal communications devices
- Internet

Meanwhile, ITS MARTA '96 concentrated on:

- The AVL component, which would provide fleet management and passenger information
- Passenger Information Devices (PIDs)
- Automated Passenger Counters (APCs)
- Automated transit itinerary planning

In late 1995, GDOT began holding weekly Systems Integration meetings. The intent of these meetings was to coordinate the multiple contracts, agencies, and activities under way in deploying the regional ATMS. All agencies were invited to attend the meetings. Typically the ATMS contractor, TRW, officially conducted the meetings, ensuring that contractors and agencies important to specific and current issues were present. These meetings proved especially helpful in coordinating construction contractors that were performing work that was highly interrelated. Without specific direction in the contract documents other than to coordinate with related work, the necessary detail to connect communications trunks, to integrate the Atlanta TIS and the FOTs, and other work could not have been accomplished without these systems integration meetings. The FHWA served as a catalyst and coordinator during these meetings. As the FHWA was not one of the operating agencies, it provided a unique, balanced perspective that moved agreements forward. (36)

3.4 1996 ONWARDS—THE OLYMPIC EXPERIENCE AND LEGACY

In January 1996, ARC and ACOG initiated a targeted Travel Demand Management (TDM) program aimed at commuters (Commute Connections Network) and the freight industry to reduce travel demand during the Olympic Games. The TDM program included newspaper advertisements and articles, television and radio broadcasts, and a program that targeted major employers. Their (37) efforts proved highly successful, with Olympic period traffic volumes occurring much earlier than usual, and with lesser peak-hour volumes.

Also in 1996, the GDOT HERO program was officially inaugurated on January 17. GDOT HERO fleet training had begun in the summer of 1995. Their official kick-off was an important milestone, putting into practice the region's new, pro-active approach to incident management. (38)

ARC, in conjunction with the Department of Defense (DOD), held a series of exercises at the TMC to test the incident management procedures developed for the OTS. In January and March, two table-top exercises were held, followed by a command post exercise in April and an ACOG operations post exercise in June. The table-top exercises used hypothetical scenarios to draw operational reactions from participants. This enabled agencies' procedures to be documented, coordinated, and integrated. The commercial post exercise repeated the table-top exercises but with agency staff placed at their respective games locations. The output of this process was the Standard Operating Guidelines, and an incident response matrix.

Activity in 1996 focused on completing the ATMS. With little time available for other activities, interagency coordination was focused on field construction and system integration in 1996. The final round of construction commenced with the letting of contracts for CCTV, signal upgrades and CMSs for the counties, county signal re-timing projects, and freeway CCTV and VID cameras. (39)

Additional contracts were advertised and then withdrawn and shelved due to resource constraints including ATMS work in Savannah and City of Atlanta arterial CMSs. This work was accomplished after the games.

The GDOT TMC and MARTA TIC opened in April 1996, followed by the TCCs in July. The completed elements of the Phase I ATMS and ITS MARTA '96 programs were essentially field tested during the Olympic and Paralympic Games in July/August 1996. All of the elements in place during the games showed that ITS provides valuable tools to improve the access to and flow of transportation systems. (40)

3.5 SUMMARY

The timeline reveals that the Olympic Games was the trigger to fulfill the local vision for ITS deployments in Atlanta via ISTEA, which provided an initial funding source. While local agencies coordinated with each other to plan transportation operations for the games, no games-related needs or roles were identified for the ATMS during the conceptual design stage. This was because the regional ATMS was necessary even without the Olympic Games. As the games approached, development of the ATMS and transportation planning for the games took mostly separate tracks, although the TMC provided valuable services during the games through freeway surveillance and incident management, and as a communications hub.

There was a significant level of interagency coordination in the development of the ATMS, despite early wariness of the counties, and the delayed involvement of MARTA. Most agencies took on the NAVIGATOR needs and the Olympic Games preparation without the benefit of increased staff. Due to the immovable deadline of the games, it was perhaps inevitable that these agencies did not achieve the complete functionality hoped for by the time of the games. However, this did not compromise the success of the transportation system performance during the games. Nor does it detract from the accomplishments of the region that include a new approach to operations that crosses jurisdictional borders, that incorporates a pro-active approach to incident detection and management, and integrates across modes.

4.0 ACHIEVING ITS DEPLOYMENT IN ATLANTA

This section discusses the similarities and differences between traditional transportation projects and ITS projects. It describes the challenges of ITS programs with the use of illustrations from the Atlanta experience. The Atlanta experience also provides examples of how these challenges may be addressed. On the basis of experience in Atlanta, a set of overall "lessons learned" is developed.

Each of the discussions is followed by a set of summary points that are the lessons learned. The summary points are numbered sequentially throughout this section for ease of reference. On the basis of commonalties found in the summary points, and on the results of focus groups held with the Atlanta region ATMS partners, ARC, and Headquarters FHWA and FTA staff, the lessons learned are synthesized into a few basic areas that support the recommendations presented in Section 5.

The Atlanta region's transportation agencies faced and met a huge challenge in deploying a multi-agency, multimodal and highly advanced ITS program in a short time period—while bearing the additional burden of preparing for the Olympic and Paralympic Games. It is only through their open and generous attitude that this Case Study was accomplished. They should be viewed as true innovators and champions of ITS. By documenting their experiences and achievements, other agencies have gained an unparalleled wealth of experience. Because the Atlanta agencies looked at their experiences in hindsight, they were able to make suggestions for improvement. Simply because they have identified potential for improvement, it does not lessen their accomplishment. They were highly successful and achieved a remarkable level of technological, and interagency functionality that is, at the time of this report, unparalleled in the United States. The successes of the Atlanta ATMS partners can be shared through implementing these recommendations.

4.1 INTRODUCTION AND DEFINITIONS

Complex ITS programs, such as the one undertaken in the Atlanta region, require transportation agencies to expand their capabilities and modify their standard approach to projects. The NAVIGATOR program was the Atlanta region's introduction to a multimodal, integrated ITS. The NAVIGATOR experience illustrates the challenges faced by transportation agencies that are increasing their range of transportation services to include ITS.

For this report, two types of traditional transportation projects are defined:

- **Infrastructure Projects:** Such as roads, bridges, rail lines, and rail stations
- **Systems Projects:** Such as traffic signal systems, traffic surveillance systems, incident management systems, maintenance management systems, fare collection

systems, radio dispatch systems, and automated vehicle identification systems.

In addition, two types of transportation agencies are defined for this report:

- **Road Agency:** An agency responsible for the provision, operation, and maintenance of highways, roads, and bridges; also includes State and local departments of transportation, and public works departments responsible for roads and traffic.
- **Transit Agency:** An agency responsible for the provision, operation, and maintenance of bus or rail transit service.

It is typical for transit agencies to have more experience with systems projects than road agencies, and for road agencies to have somewhat more experience with infrastructure projects than transit agencies. This is a generality, and applies to traditional transportation agency roles. Being a generality, there are certainly exceptions. Road agencies are responsible for the design, construction, operation, and maintenance of roads. Thus, their organizations emphasize these infrastructure-based functions. Bus transit agencies are responsible for the procurement, operation, and maintenance of buses. To operate buses, the bus operator must be communicated with and fares must be collected. These are essentially people-to-people transactions that use systems to perform and monitor them. Thus, transit bus agencies emphasize systems. Some transit agencies, such as MARTA, are also responsible for the design, construction, operations, and maintenance of rail transit. Rail transit agencies are responsible for both infrastructure (tracks and stations) and systems (train control systems, fare collection systems) projects, and thus have experience in each type of work, whether contracted out or performed in-house.

This report outlines the traditional transportation program development, and deployment process in a step-by-step fashion. The steps developed are general, standard steps taken for traditional transportation projects. Four basic steps can be identified that are followed for traditional road or transit infrastructure (capital) projects:

- Initial Planning: All activities that culminate in application for funding including early interagency coordination, regional planning activities, and early concept development
- Procurement: All activities related to obtaining assistance to design a project
- Design: All activities related to creating the final project design
- Construction: All activities related to implementing the project design on the basis of the plans and specifications

The steps are based on major project milestones, and may not align completely with actual processes at specific agencies. The general steps are used to structure the discussion of the similarities and differences between traditional and ITS projects.

4.1.1 Definitions

Some definitions are needed to standardize the terminology used in this section.

Field Devices: Those components of ITS that are found in the roadside environment including traffic controllers, vehicle detection devices, cameras, CMSs, and communications trunks.

Control System: The hardware/software system housed in the TMC, TCC, or TIC that electronically addresses and controls the ATMS field devices, processes ATMS information, and controls ATMS communication capabilities.

System Implementation: The process of integrating hardware and software to enable a control system.

Atlanta ATMS: The regional multimodal transportation management system program, led by GDOT, including the six TCCs, one TIC, and their connections to the TMC, the field devices, and the TMC, and internal computer system. Excludes ITS MARTA '96 (beyond the TIC and connection to the ATMS), the ADAS and Kiosk FOTs, and the Atlanta TIS.

ITS MARTA '96: The collection of projects led by MARTA including AVL/APC, and the PIDs. Does not include the ATMS portion of the TIC, and connection to the Atlanta ATMS.

NAVIGATOR: The complete set of projects that comprise NAVIGATOR, which includes the Atlanta ATMS, and ITS MARTA '96, the ADAS, and Kiosk FOTs, and the Atlanta TIS.

ITS Project: An individual component of an ITS program, e.g., the communications trunk portion of NAVIGATOR.

ITS Program: A group of related ITS construction or implementation projects, such as NAVIGATOR.

4.2 FIRST STEPS IN THE PROCESS—INITIAL PLANNING

Initial planning includes early program definition, and, if needed, early interagency coordination. For each of these two elements, there are similarities and differences between traditional transportation projects and ITS projects.

4.2.1 Early Program Definition

At the earliest stages of program definition, projects to address transportation needs are defined in broad terms. For example, a new road corridor may be identified to respond to traffic congestion, but the alignment, number of lanes, the project impacts on the natural, and built environment, and the details of any needed interagency agreements are not understood in detail. Similarly, a transit agency could identify a need to upgrade its fare collection system to improve customer satisfaction, and reduce money handling. The details of the fare collection system, such as whether it would use combination cash/token fareboxes or "Smartcards," would not yet be identified. However, adequate information, and an estimated project cost are assigned to begin considering the project in the agency's, and the region's transportation improvement program (TIP).

The early program description for an ITS program is even more general. ITS program descriptions are more often functional than physical. For example, ATMS programs can be defined as "systems to provide traffic surveillance, incident management, and traffic control" in a given region—a functional description. This contrasts with an early program description for a road, which would not be defined as "a system to move cars" from one place to another, but would be described as a road connecting one point with another—a physical description. Thus, the contrast between traditional transportation and ITS programs is already distinct at this early stage. Traditional transportation programs are usually described in physical terms and ITS programs are described in functional terms.

The fact that early descriptions of ITS programs are more often functional than physical illustrates that ITS programs can be more difficult to identify in terms of the physical components than traditional programs. This results in increased difficulty in establishing cost and schedule estimates for many ITS programs. To develop cost estimates for ITS programs, more information is needed than is usually available at the early program stage. Communications systems must be identified as hard-wire, wireless, owned, leased, or a combination of these. Detection technology must be identified among a variety of options (loops, video systems, microwaves, etc.). These choices have major cost implications and cannot be determined without more information than is usually available at the pre-funding stage. Nor can these types of ITS components be readily estimated on a per-mile or other standard basis.

Because ITS programs are more difficult to define than traditional transportation programs, more effort is needed to identify, and define ITS programs in the early stages. If this work is not done, ITS programs risk being defined on the basis of available funding. The problem of designing programs to fit budgets is not unique to ITS. However, unless more effort is invested early in the process, ITS programs are at *higher* risk of being inadequately funded than traditional transportation programs.

4.2.1.1 The NAVIGATOR Experience with Early Program Definition

The need for an ATMS was identified in the 1977 regional plan to be implemented sometime in the following 20-year period. The Olympic Games produced an immediate need for the regional Atlanta ATMS. There was little time between the September 1990 announcement that the games would be held in Atlanta and the time when preliminary proposals for allocation of 1991 ISTEA moneys needed to be submitted. It was not possible to prepare a complete preliminary definition of the regional Atlanta ATMS and the system costs. Therefore, the program was funded with little definition behind it. This process may not be typical of many other ITS projects, as the Atlanta ATMS was defined in a constrained time period. An exception within the program that may be more typical was the City of Atlanta's traffic signal system replacement project. The City of Atlanta had performed a study to define and estimate the cost of the City's upgraded traffic signal system.

Using the very limited information available, a cost estimate was prepared for the Atlanta ATMS request for ISTEA funding as a demonstration project. At that time (in early 1991), the system was envisioned as a GDOT/City of Atlanta coordinated traffic signal system. The estimate was primarily based on the more detailed cost estimate developed for the City of Atlanta traffic signal and control system upgrade, and included no freeway ATMS needs or costs.

Soon thereafter, GDOT began the process of educating itself about regional ATMS systems so it could better define the scope of the program. In anticipation of the ATMS, FHWA sponsored a 2-day workshop in July of 1991. The workshop was hosted by the Georgia Tech Research Institute's Transportation and Research Education Center, and attended by national ATMS experts from FHWA, other State DOTs, State, and local transportation officials from throughout Georgia, and national ATMS technology leaders. The purpose of the workshop was to propose demonstration projects that would showcase the latest in advanced transportation technologies, and serve the Atlanta region's transportation needs. This workshop was instrumental in developing the first ITS program scope that included a multimodal, multiagency, regional, integrated ATMS concept. It would be the first time such an architecture would be implemented in the United States. In addition, several new, untried technologies were proposed such as an automated vehicle identification (AVI) system.

FHWA sponsored a tour of West Coast TMCs in February of 1992 for staff from GDOT, the City of Atlanta, ARC, and FHWA. These agencies agreed that a multiagency strategy was well suited to the Atlanta region. They sought examples of interagency cooperation and coordination on an operational level and demonstrations of ATMS technology. The tour included visits to the following ITS control centers:

AGENCY	ITS Control Centers Visited
WSDOT	I-5 Traffic Systems Management Center (Seattle) I-90 Tunnel Control Center (Mercer Island)
CALTRANS	District 7 Traffic Operations Center (Los Angeles) District 11 Traffic Operations Center (San Diego)
City of Anaheim	Traffic Control System Center
City of Los Angeles	Automated Traffic Surveillance and Control (ATSAC) Center

The group returned with an improved understanding of the workings of control centers, and ATMS technologies, particularly those in use for traffic surveillance, incident management, and response, CMSs (variable), traffic signal control, and ramp metering. They also found that the scale of interagency operational coordination envisioned for Atlanta was much greater than the level in place anywhere in the United States at the time. The host agencies were supportive of the regional ATMS concept. However, since no previous ATMS had been developed based on that concept, none of the host agencies were able to provide an example of a framework to use to pursue such a project.

The main result of the trip was an improved ability to define the technologies, and functions planned for the regional ATMS. The program RFP, released in July 1992, was modified to reflect this new knowledge. The ISTEA line item funding including the local match was $72 million. GDOT felt confident that this funding level would be adequate to provide the functionality it had requested in the RFP, but did not have the information needed to confirm it. Such information would require preliminary studies, and coordination with the ATMS partner agencies before the final cost estimate could be developed.

With only 4 years remaining before the 1996 Olympic Games, GDOT had to proceed without total cost confirmation. It was GDOT's intent to refine the scope of work, and cost estimate after more work was completed. In April 1994 the total cost of the regional ATMS program (all ATMS elements, including the TMC, the ATMS Control, the six TCCs, the field devices, and communications trunk, the individual traffic signal upgrades, arterial CMSs, cameras, etc.) was increased to approximately $150 million—more than twice the original estimate.

One of the challenges faced in the Atlanta region, and indeed throughout the United States, was that of quantifying the potential benefits of ITS. Even though there was anecdotal evidence available in 1991 (at the time the concept was being developed), little quantitative data had been collected from the few ITS deployments in the United States that could be used to allow transportation engineers, and planners to apply specific ITS solutions to specific problems. Tools existed at the time to estimate benefits from improving traffic signal timing, and coordination and from ramp metering. But tools were not available to quantitatively estimate benefits from incident management, traveler information, bus AVL and APC, and other ITS projects. This made it more difficult to gain program support at all levels, and also made it difficult for ARC to integrate the ITS programs into the regional planning process.

Since the USDOT has collected more ITS cost, and benefits data, and continues to do so. Most elements of the NAVIGATOR regional ATMS, and the ITS MARTA '96 program were subject to evaluations. Although useful benefits information was gained from these evaluations, the lack of a set of baseline data ("before" data), and the fact that the evaluation occurred before all of the systems were operational limited the evaluation's usefulness. It is interesting to note that, even though operational benefits of the NAVIGATOR program were not quantified, all participating agencies agree that the benefits exist, and are significant, now that they have experienced the system. This may indicate that some ITS benefits are difficult to quantify. It also underscores the usefulness of touring other ITS deployments, so that agencies can learn firsthand which systems provide benefits for which agencies and situations.

The MARTA, and GDOT ITS programs originated in different ways at different times. As noted in Section 3, FTA, and MARTA agreed to the concept of showcasing ITS projects during the Olympic Games. GDOT had also maintained an informal advisory, and informational connection with MARTA, supporting its decision-making process, and assisting in developing the ITS concepts that supported transit information systems. Unlike the regional ATMS, which was a larger, more complex system, the ITS MARTA '96 program relied on technologies that had already been tried elsewhere. The program was intended to improve the public's access to transit information, improve transit operations, and improve the public's perception of transit service.

MARTA consulted with several industry peers to refine the system concept, and the scope of work that would be published in the RFP to potential system contractors. MARTA met and/or communicated with representatives from five peer transit agencies that had installed, or were in the process of installing, APTS components as part of their transit operations. These transit agencies included:

- Mass Transit Administration—Baltimore, Maryland
- Ann Arbor Transportation Authority, Michigan
- METRO Transit, Seattle
- Metropolitan Transit Commission, Minneapolis
- Houston Metro, Houston

Meetings were held with representatives from these agencies to review the system concept planned for the ITS MARTA '96 program. In addition to meeting, and communicating with representatives of the five listed transit agencies, MARTA contacted by telephone all transit agencies known to be involved in ITS planning, and deployment. The initial review resulted in major changes to MARTA's system concept on the basis of the lessons learned from the experience of these transit agencies in implementing their own ITS projects. Two of these agencies continued to advise MARTA throughout the procurement process with comments for the continued refinement of the RFP, and technical assistance during the proposal evaluation period. In addition, MARTA brought these consulting transit agencies together with various staff from departments in MARTA for comments, and advice on the final selection of the contractors.

MARTA also consulted with the Regional Transit District in Denver to gain insight into its recent experience with AVL deployment. Denver installed the same system from the same contractor as was ultimately selected for MARTA—their comments were particularly helpful. GDOT also assisted MARTA in its program. GDOT had already learned many useful lessons regarding ITS deployments by the time MARTA's program was under way. Since the MARTA system would be linked to the regional ATMS so the kiosk, and TIS servers could extract transit information, and process it for use in the kiosk, and TIS projects, GDOT's assistance in scoping was essential to the program success.

Since the systems MARTA was procuring had already been installed elsewhere, there was good cost information available. MARTA was able to perform the necessary level of program definition to adequately scope, and cost the APTS components before the funding request was submitted. It should also be noted that the ITS MARTA '96 program was less complex than the Atlanta ATMS. MARTA's funds were secured from internal FTA sources (supported by FHWA funds transferred to FTA). Unlike GDOT, timing did not inordinately constrain MARTA's early program definition process. GDOT was constrained by the timing of the 1991 ISTEA, requiring an early program definition to secure funding within months.

4.2.1.2 Summary of Early Program Definition

1. ITS program operation and technology selection need to be investigated and outlined to develop robust early program scope, and cost estimates. Doing so requires considerable up-front effort—more than is typical for traditional transportation projects at the same stage.
2. There is not enough cost or benefit information available to assist agencies in matching ITS programs with needs, with gaining support, and to help the MPOs integrate ITS into the transportation planning process.
3. Incorporating the experience and knowledge gained from other ITS implementations improves early program definition. Scanning tours are one method to learn from other agencies and can help in understanding ITS benefits.

4.2.2 Early Interagency Coordination

Early program coordination is key to the success of any transportation project that crosses jurisdictional boundaries. Before enactment of the 1991 ISTEA, most agencies did not plan their transportation improvements in a regional, coordinated fashion. Since that time, strides have been made to coordinate transportation needs, and to identify projects that meet regional needs. Therefore, it is likely that more needs (and projects to meet them) that cross jurisdictional boundaries are identified now than have been in the past, thus increasing the need for early project coordination. The regional emphasis on transportation programming has also improved the ability of agencies to agree on common goals, since each agency's transportation program must contribute to, or at least not be in opposition to, regional goals. In addition, the Metropolitan Planning Organization (MPO) leads the forum for interagency transportation planning coordination. MPOs are often considered to be reasonably unbiased, and agencies can use the MPO resources to assist in developing consensus. However, no agency is *required* to agree to anything. Education, persuasion, and political clout are necessary tools in developing agreements.

Most traditional transportation projects do not require extensive interagency coordination, and agreement. For traditional transportation needs, coordination typically occurs only if agency boundaries overlap. For example, Cobb Community Transit, and MARTA might coordinate to accommodate transfers from one system to another at adjacent or shared transit stops. Similarly, the City of Atlanta, and Fulton County might coordinate traffic signal timing on an arterial that crosses both jurisdictions. Most agencies have or are now working to improve interagency cooperation, and coordination on a regional basis for a variety of reasons. The regional transportation planning process works best when agencies understand the transportation needs on a regional basis, and good cooperation prepares agencies to meet needs that cross borders.

For traditional transportation projects requiring coordination, the person-to-person interaction, and coordination often ends once an agreement is made. For example, Cobb Community Transit (CCT) would agree to adopt a particular bus operating schedule, and MARTA to another. One agency might agree to let another operate a portion of its signal system. In each of these examples, on-going operations (i.e., implementation of the agreement) are performed independent of one another. Coordination is needed only on an intermittent basis to maintain good operations.

In contrast to most traditional transportation projects, the integrated, multiagency ATMS concept used in Atlanta requires agencies to operate collaboratively on a continuous basis to maximize benefits system wide. The integrated, multiagency ATMS concept responds to the fact that transportation needs are independent of agency boundaries. It requires transportation operating agencies to adopt a new paradigm that places a reduced emphasis on operations within jurisdictional, and modal boundaries, and a greater emphasis on multimodal operations throughout the region. Under this model, interagency coordination does not end when an operational agreement is reached, because integrated ATMS operations require on-going interactions. For example, a regional, integrated ATMS can include incident response plans that employ signal timing changes, and traveler information to divert traffic from the incident queue to other corridors in multiple jurisdictions. This capability would require real-time information sharing including traffic flows throughout the region, locations of incidents throughout the region, and information about special events that might affect a diversion plan. The final decision on a diversion plan would not likely be a unilateral one, but would be collaborative, involving all affected agencies.

These are new concepts, and new ways for agencies to work together that require not only the support of the traffic engineers, but political support as well. As with any other major process changes in transportation, it cannot be expected that this type of radical change can be effected in a short time period. An analogy is the shift to regional-based planning, which began with the 1991 ISTEA. Throughout the United States, there are examples of regions that have adopted the concepts of regional planning, and others that, for various reasons, are unable to produce transportation plans that are based on regional goals.

4.2.2.1 <u>NAVIGATOR Experience with Early Interagency Coordination</u>

The regional ATMS concept was brought to the counties by an enthusiastic GDOT that understood the potential system benefits if the agencies operated interactively. GDOT was eager to share these benefits with the regional DOTs. The operating concepts included:

- **Integrated Ramp Metering and Traffic Signal Control:** A plan to tie together the operations of ramp meters with adjacent traffic signals to optimize overall interchange operations. Ramp metering operations began within the City of Atlanta in 1997. Integration with the 170/2070 based traffic signal system will be implemented in the future.
- **Incident Data Sharing:** The ability to post incidents, construction closures, and special event information on a shared database. Each agency connected to the regional ATMS can access the information and use it to make decisions regarding traffic operations in its jurisdiction. (This function has been implemented.)
- **Semi-Automated Traffic Diversion Plans:** The ATMS has the capability to recommend, and for ATMS operators to implement, pre-programmed traffic diversion plans in response to incidents. The diversion plans could include multiple agencies' facilities. If an incident occurs, it is possible to post messages on CMSs and to broadcast messages via the HAR directing drivers to alternate routes. Signal timing plans could be automatically implemented supporting the diversion route. The plans could divert traffic from arterial routes to freeways or

vice versa. (This function has not yet been fully implemented. Changeable message signing can be used to divert traffic from incidents. Some diversion plans have been agreed on by the affected agencies, but have not yet been tested in "real time" as no incident requiring diversion has occurred. Many signal timing plans have been pre-programmed for potential diversions, and will be available from any TCC or the TMC.)

- **Ability to Operate All Connected Traffic Signals from the GDOT TMC:** Any traffic signal that is connected to the ATMS can be addressed and operated from the TMC. GDOT staffs the TMC on a 24-h basis, while the TCCs are staffed typically only during normal working hours, and during peak traffic periods. Traffic signal engineers at the counties and the City of Atlanta are available on-call to respond to any traffic signal malfunctions or serious incidents that occur during the off-hours. The intent of providing this capability at the TMC was to allow for a more rapid response to incidents, and signal malfunctions. In addition, since the TMC was to be staffed around the clock, GDOT thought it would be helpful to provide this resource to the counties and City of Atlanta, thus reducing their off-hours workload. (This function has not been implemented. The City of Atlanta is currently being brought on line for this capability.)
- **Shared Camera Images:** As described in Section 2, each of the agencies connected to the regional ATMS can access images from any other agency's cameras. They can also operate the pan/tilt/zoom controls of CCTV cameras. The agency that owns the camera can override any other's access commands, and take control of the CCTV camera controls when in need. (This function has been implemented.)

Staff at the county DOTs also agreed with the regional, integrated ATMS concept in principle, but had several concerns. They were concerned with many of the proposed functions, particularly those that might allow another agency (GDOT) to control their traffic signals, and that might divert traffic from highways to arterials within their jurisdictions. They wanted clear assurances of funding support for construction. They also wanted clear benefits to be demonstrated. In addition, GDOT had originally approached the counties with the concept of changing all National Electrical Manufactures Association (NEMA) controllers to 170s, which would be easier to address electronically, and allowed for improved operations. The counties were pleased with the NEMA systems they had in place, and did not wish to change over to 170s. Clayton, DeKalb, and Gwinnett Counties have begun a program to change to 170s, based on the benefits of the ease of communications via the ATMS. Cobb County is still reviewing the question, and Fulton County remains a NEMA system. Many of the ATMS partners for Phase 2, and other future phases have already agreed to change to 170 controllers, based on the additional benefits that can be exploited due to the change. The controller issue is described in more detail later in this section.

Due to timing issues related to funding, the project concept was developed quickly. Unfortunately, time did not permit GDOT to forge the collaborative relationships, and develop the shared goals critical to the regional ATMS concept. The counties were approached after preliminary concepts had been developed. In addition, they were concerned that they had not been allowed to participate in the early decision-making process, and that they were presented with a design developed without their input, and that their input would not be considered in any future design decisions. Some of the counties felt that there was a potential for freeway traffic to be diverted onto county roads via the use of freeway CMSs and HAR. The CMS coverage on county roads was sparse, and some of the counties felt that they had a lesser ability to control diversions. As a result, the counties were concerned with the ATMS concept since they did not feel that they would have the same capabilities as GDOT to control traffic. These issues created barriers to cooperation. If permitted adequate time, GDOT could have worked to create a better regional consensus; however, since deployment, trust, and cooperation have been demonstrated, and have grown between the transportation agencies.

The ATMS member agencies have agreed to participate in the regional ATMS operations. This will require an on-going operations forum to meet regularly, which will allow the agencies to work on adding to the repertoire of diversion plans, and other ATMS operations. In addition, although the agencies have agreed to coordinated maintenance, details of the maintenance arrangements have not yet been developed.

Being a transit operations agency, rather than a roads agency, MARTA did not have the same issues as the counties in considering the benefits of participating in the regional ATMS. The Atlanta TIS project, which is connected to the ATMS, would allow MARTA to provide transit information at kiosks and on the Internet. (Real-time transit information was not available during the Olympic Games.) The Kiosk FOT would also allow transit information to be dispersed to the public. GDOT had considered MARTA as a partner in the early planning, but MARTA did not have a plan to include ITS components in its system at the regional ATMS project outset. MARTA was planning to provide Olympic Games operations using its existing operations infrastructure.

After MARTA, and FTA agreed on the elements of the ITS MARTA '96 program, they felt that they could share their new information capabilities with the region via the regional ATMS. With new capabilities on the horizon, including real-time bus schedule information, GDOT, and MARTA worked together to develop a proposal to connect to the regional system. GDOT shared with MARTA the benefits of accessing regional incident information from all of the member agencies that could help them route Olympic buses around incidents. MARTA also believed that the CCTV camera images available from the regional ATMS would be valuable. During the Olympic Games, MARTA found the camera images to be more useful than it had anticipated as it was able to view buses stopped in traffic and to view queues of people waiting for transport at the Olympic Stadium.

4.2.2.2 Summary of Early Interagency Coordination

4. Begin early to promote, and develop coordinated regional operations, and ATMS capabilities. Develop the ITS concept in a collaborative forum.
5. Continuous interagency coordination from planning through operations, and maintenance is critical to the success of integrated regional ITS deployments.
6. ITS programs require more interagency coordination than typical for traditional transportation programs.

4.3 PROCUREMENT

The procurement process includes both funding, and contracting for the program. Specifically, transportation funding includes funding for the transportation program and funding for staff to manage the program, and the operations needs. Contracting for transportation projects is a process that is defined by Federal, State, and local laws and guided by policies.

4.3.1 Funding the Program

This section illustrates one of the similarities between ITS and traditional transportation projects. Both must follow the same statutes and policies designed for transportation funding. However, there are some differences. For example, ITS projects require more dollars be spent on maintenance and operations as a proportion of overall life-cycle costs than do traditional transportation projects. ITS also requires procurements that recognize the specialized nature of the work required to deploy ITS, in contrast to traditional transportation projects. In recognition of the need to improve the procurement process, in addition to traditional Federal aid transportation procurement rules, FHWA has developed new contracting opportunities (e.g., System Integrator, and System Manager procurements) that can be applied to ITS projects. In addition, funding requirements have been modified to allow for the needs of ITS. For example, local agencies may now apply for and use National Highway System (NHS) funds for ITS operations.

For air-quality non-attainment regions, such as Atlanta, the complete regional transportation plan must be evaluated for conformance with air quality goals established in the Clean Air Act Amendments of 1990 (CAAA) and incorporated in the 1991 ISTEA. A new category of funding, Congestion Management and Air Quality (CMAQ), was created at that time to supplement other funding mechanisms and to encourage regions to submit projects that led to improved air quality.

Both the air quality conformity ,and CMAQ funding processes were new to the Federal-aid process. The Environmental Protection Agency (EPA) and USDOT began defining conformity rules, including identification of specific types of projects that would be exempt from such rules. In addition, the EPA began developing models to quantify air quality benefits on a regional level for complete transportation programs, and on a more localized level for individual transportation projects.

As with any new process, there have been several modifications, and additions to policies, and procedures since the programs began. Such modifications reflect a growing, and improved understanding of the transportation-air quality linkage, and provide resolution of conflicting views regarding project air quality benefits. For example, in the early years of ISTEA, a debate began concerning the eligibility of HOV lanes for CMAQ funding. On one side of the debate, an HOV lane was considered a capacity expansion that was contrary to air quality goals. On the other side, HOV lanes were seen as a key tool to encourage and increase carpool, and transit use, thus reducing overall emissions. This issue was evaluated at the Federal level, and guidelines for justifying the air quality benefits of HOV lanes were developed. These guidelines included a provision that "take-away" HOV projects were assumed to comply with CAAA goals, and provided guidance for the conduct of the necessary air quality modeling.

More difficulties arise when projects are proposed for which air quality benefits are difficult to quantify such as carpool promotional programs. It is also difficult to quantify the air quality benefits of some ITS projects such as incident management programs. The NAVIGATOR program included projects for which quantifying air quality benefits was difficult, as described below.

4.3.1.1 <u>The NAVIGATOR CMAQ Funding Experience</u>

The Atlanta Regional ATMS deployment was funded using several sources: the original project funds were programmed as a "line item" demonstration project in the ISTEA bill. Other sources included CMAQ funds and Surface Transportation Program funds.

The Atlanta metropolitan area is an air quality non-attainment region, and was in non-attainment when the NAVIGATOR project was developed. In fact, one of the goals of NAVIGATOR was to improve air quality. The regional planning process followed the requirements for CMAQ funds in compliance with the CAAA. However, early CAAA requirements were based on less sophisticated transportation-air quality models than later became available. Model sophistication progressed during the time period encompassing the NAVIGATOR project. CMAQ funds require that *quantitative* air quality benefits be shown *when possible.* The scope of projects for which air quality benefits were possible to quantify has expanded with time, and with the development of new air quality models.

ARC submitted a quantitative air quality benefits analysis for the Atlanta ATMS program on the basis of rough estimates of delay reductions. At least twice during the ATMS deployment, GDOT, (and ARC) was asked to provide more precise quantitative air quality analyses to support the information it had provided in the original CMAQ funding request. Specifically, GDOT had submitted a request for CMAQ funds for elements of the incident management program, including portions of the communications trunk, variable message signs, and GDOT HERO vehicles. Although it was clear that the incident management program would result in air quality benefits, it was very difficult to use models to quantify the benefits of these specific elements. The incident management projects were eventually funded via CMAQ after a more detailed quantitative analysis was provided that relied on newer modeling processes.

In addition, CMAQ funds were requested for the initial set of 88 traffic signal upgrades in the City of Atlanta. Again, a more precise set of air quality benefits was requested than was initially submitted by ARC. This required a type of modeling that had not been done by GDOT or ARC before. Using additional, more detailed, supporting findings, the traffic signal project was eventually funded.

As the ATMS program progressed, and Atlanta grappled with the task of devoting more resources to improving air quality, the ARC decided to direct CMAQ funding increasingly more toward those projects that focused on air quality benefits rather than congestion mitigation benefits. Since the ATMS, and signal improvements were primarily a congestion mitigation type improvement, and a significant portion of CMAQ funding was already programmed for ATMS projects, subsequent CMAQ funding was directed toward air quality projects. In the end, GDOT relied on non-CMAQ funding sources for more traffic signal upgrade projects than it had originally anticipated.

Each of these difficulties required that scarce staff resources be assigned to remedy the funding issue. To ensure that no program delays would occur, GDOT allocated its own funds to some projects that were in the midst of funding category questions to get them under way. Despite this challenge, GDOT was able to complete many of the most critical components of the regional ATMS in time for the Olympic Games.

4.3.1.2 The NAVIGATOR Experience Integrating With Regional Funding Processes

As mandated by ISTEA, the Atlanta region's transportation funding is based on multimodal, multijurisdictional needs, and is coordinated by ARC. ARC provides a forum for interagency coordination, and is also responsible for regional transportation modeling, including air quality modeling. ARC is responsible for the development of the Transportation Improvement Program, which programs projects within the metropolitan area for funding under U.S. Code Title 23.

The regional planning process had identified freeway incident management strategies, and the need to upgrade the City of Atlanta's traffic signal system in its long-range planning documents well before the 1990 Olympic Games announcement. As soon as specific ATMS projects were identified, they were incorporated into the region's transportation and air quality models by ARC. These models were used to support the Federal aid funding requests for not only the ATMS but for all transportation projects in the region. Thus, the ITS and traditional transportation funding processes were well integrated.

Although MARTA and FTA performed a fairly detailed qualitative needs and benefits analysis of the ITS program, this analysis did not follow MARTA's transportation planning process, causing difficulties in final program definition and identification of funding to support the investment. MARTA creates long-range and annual plans that include all projects and their funding sources. ITS MARTA '96, and its link to the regional ATMS were never contemplated in these processes. MARTA originally believed that it would be able to meet Olympic Games needs using existing and conventional transit systems. Therefore, the ITS program was proposed at a time that was outside of MARTA's, and the region's normal project, and funding planning cycle. Because of this, all funds for MARTA's ITS program were additional to its previously budgeted funding, and had to be special transit funds, specific to the ITS MARTA '96 program. In addition, the regional transportation plan was amended to add MARTA's ITS program.

The project description evolved over a period of 18 months after the FTA/ MARTA meeting and was finalized in February 1995. During this time, MARTA and FTA revised the work plan several times in an attempt to meet the needs of the transportation system and to take advantage of the opportunity to showcase advanced technologies during the Olympics. In addition, FTA began the process of identifying and assembling the necessary funding to develop the grant that would pay for these investments in transit technology.

4.3.1.3 NAVIGATOR Experience Funding a Multiagency Program

FHWA distributed the complete regional ATMS program funding through regular Federal-aid channels to GDOT (excluding the MARTA TIC and ITS MARTA '96 programs, which were funded to MARTA via FTA). The program could have been managed individually by GDOT, the City of Atlanta and the counties, but they all agreed to have GDOT manage the overall program and funds because of their own staff resource constraints. As a result, only two agencies' funding requirements (FHWA and GDOT) had to be met. As a result, FHWA could oversee the entire program through its oversight of GDOT. Last, FHWA had a single agency to work with regarding the funding needs and requirements for the regional ATMS. Another benefit to GDOT management of the complete program and funding is that it allowed the funds to parallel the overall system development priorities. GDOT was able to identify and prioritize ATMS projects on a regional basis.

4.3.1.4 Summary of Program Funding

7. Many ITS components are difficult to incorporate into standard transportation-air quality models.
8. ITS programs should be incorporated into regional transportation plans.
9. If transit ITS programs are not considered as part of the usual budget, and funding cycle then special FTA grant agreements may be required that can introduce other funding conditions and funding schedule issues.
10. The current Federal-aid (roads) funding processes and Federal-local (transit) funding relationship work for ITS.
11. Coordinating the management of a multiagency regional ATMS program can be simplified if a single agency is selected by the ATMS partners to manage the program.

4.3.2 Funding Staff Needs for the Program

Staff needs at transportation agencies are based on the funds allocated to planning, design, construction, operations, and maintenance. In addition to performing this work in-house, a portion of staff time may be allocated to managing consultant work for these same functions. Road agencies have a long history of managing consultants, and since they are also capable of performing the same road-related work as the consultants, they understand the project technical, management, and decision needs. Occasionally, if a major construction program is planned, program management services are contracted out. However, it is typical for the agency to reallocate its own staff to manage large programs.

Transit agencies typically focus on the planning, operation, and maintenance of their bus and rail systems. It is common for staff to have expertise in the design, and construction of transit systems or rail transit infrastructure. Outside consulting assistance is usually procured to act as agency staff to help manage other outside service contracts to design and construct infrastructure, or to procure systems.

ITS programs require special expertise not usually found at traditional transportation agencies. Outside contractors are usually hired to plan, design, and implement ITS projects. More and more often today, operation, and maintenance of ATMS systems is being contracted out to private concerns. In addition, the skills needed to manage outside consultants who perform work outside of the traditional transportation staff's expertise are different from the skills needed to manage consultants performing work in which the transportation staff is expert. In other words, the skills needed for a road engineer to manage a road design project are different from those needed for the same engineer to manage the design of an ATMS—because the typical road engineer does not have expertise in ATMS design.

Funding new staff positions is difficult for most public agencies. At transportation agencies, it requires political support from the highest levels. Cities and counties must get budget approval directly from their elected officials. DOTs must work with their State legislatures. Transit agencies, which typically have a mix of local, regional, State, and Federal funding sources, may have to justify their needs at all of these levels.

4.3.2.1 The NAVIGATOR Experience Funding Staff Positions for Program Planning and Design

GDOT entered into the ATMS program in 1991 with few additional staff, even though it was clear that there would be much additional work from the Olympic Games alone. Early on 12 staff positions were converted from the Traffic Operations Office to the ITS office. Many of these staff continued to meet their original roles in Traffic Operations and added their ITS roles to their work. In addition, the time constraint on the project imposed by the Olympic Games increased the need for staff time to manage the NAVIGATOR program, and consultant work. Existing staff were spread very thin in order to maintain their original job commitments, to manage the ATMS project, to coordinate with other agencies involved in the program, and to assist with Olympic planning. In addition, the ATMS concept was new to the Atlanta region, and none of the GDOT staff had ever been involved in ATMS planning, system implementation, ATMS hardware, and software development, managing ATMS consultants, or operating, and maintaining an ATMS. Within a few years, 12 positions including ATMS engineers, computer software and hardware specialists, and electronics specialists, were approved by the legislature and added exclusively to the ITS office. Later, GDOT reallocated some 70 additional positions from within GDOT to staff and operate the ATMS. All of these positions are State funded.

Technical assistance was provided by the FHWA Georgia Division office. However, this assistance was provided in a new way. In the past on road construction projects, the FHWA Georgia Division staff reviewed technical and construction documents only after they were completed. For the NAVIGATOR program, FHWA Georgia Division staff worked side-by-side with GDOT staff on a daily basis in the process of developing program requirements and technical documents. When final documents were provided to FHWA for approval, the FHWA staff were able to perform the review much more quickly and with a better understanding than if they had not participated in the daily process.

This approach was well suited to the complexity and time constraints of the NAVIGATOR program. It promoted improved relationships between GDOT and the FHWA Georgia Division staff and reduced FHWA review time, helping to meet the tight schedule. This approach was so successful that the FHWA Georgia Division office plans to continue to pursue this type of partnership working relationship with local agencies in all future Full Oversight projects—ITS and others—meeting on a frequent basis to reduce the time involved in the review process and maintain strong relationships with local agencies.

In addition to FHWA staff, an independent consultant was hired by FHWA to assist with program development and review. The consultant was brought in to review project technical documents, and occasionally to participate in meetings when technical aspects of the program were discussed. Both GDOT and FHWA found the independent consultant's advice to be very valuable.

4.3.2.2 ITS MARTA '96 Experience Funding Staff Positions for the Program Planning, Design and Construction

Like GDOT, MARTA staff had no direct experience managing ITS consultants or ITS projects. MARTA typically budgets a fixed percentage of its project costs for outside management support and continued this practice for the implementation of the ITS MARTA '96 project. MARTA awarded a consulting contract to provide overall project management and quality control for the ITS program, including grant administration, engineering and design review, and project management. The services were explicitly called out in a line item in the grant agreement.

The consultant was responsible for overall project management of the contractors that were designing and building the ITS MARTA '96 project. MARTA has a long history of using consultants for this type of support on similar systems projects such as the recently installed train control system and several extensions to the rail network. The consultant also provided quality control services by performing on-site field inspections of contractors as they installed components of the ITS system such as electrical lines, cabling, and conduit for the fiber optic cable. In this role, the consultant was able to identify and more easily correct potential problems in the field before installations were finalized.

4.3.2.3 Summary of Funding For Staff For Program Planning and Design

12. Traditional local transportation agencies may have little ITS technical and program management skills and experience necessary for successful deployments. They may rely on outside support from peer organizations, outside experts, FTA and FHWA.

13. The traditional Federal-local, and transit program oversight and review relationship can be adapted to complex ITS deployment programs. Daily interaction can result in improved coordination technical support and reduced review time.
14. Many road agencies do not bring on outside program management assistance, and may overlook the funding needs for such assistance.
15. Many traditional transportation agencies experience difficulties in creating and funding new positions needed to manage an ITS program, and rely on existing staff or outside assistance.

4.3.3 Funding Staff Needs to Operate and Maintain the ATMS

Federal support for funding transit agency staff differs from that for road transportation agency staff. The differences relate to the history of transit, roads, and to the different nature of each type of operation.

Since the beginning of the Federal-aid program for highway construction, it has been the local agency's responsibility to operate and maintain roads, bridges, and associated roadway elements constructed using Federal funds. Local road agencies have been able to operate and maintain their facilities relatively independent of Federal involvement. Federal assistance is available for maintenance that involves reconstruction, including bridge reconstruction, or major resurfacing. These types of projects conform to the overall concept of the intermittent involvement of the Federal Government in local agency needs.

In the earliest ITS programs, the Federal funding role was consistent with its role in road projects. Federal moneys were provided for constructing ITS, and ITS components, maintenance, and operations were left to the local agencies. However, experience has shown that the cost to operate and maintain ITS systems is a larger proportion of overall life-cycle cost than for more traditional road or bridge projects. An ATMS must be directly overseen on a daily basis for it to perform at peak efficiency. Roads and bridges do not require daily, minute-by-minute, monitoring or attention.

The Federal role has changed, and will continue to change, as it relates to funding operations and maintenance of ITS, and other programs. Surface Transportation Program funds may be used for operations needs. States can avail Federal funds for operations and maintenance by budgeting for these early in the process. In addition, ISTEA (as amended by National Highway System legislation) has allowed Federal funds to be used to support staff positions to maintain and operate ITS hardware, and software.

At transit agencies, Federal funds have long been provided to support both the capital budget, and the operating budget, including staff positions. The Federal share of transit operating budgets has begun to lessen in recent years. However, if staff are required to install or maintain ITS systems, the request for budgetary approval can include Federal funding support.

4.3.3.1 The NAVIGATOR Experience Funding Operations and Maintenance Staff for the ATMS

The NAVIGATOR project funding focus was clearly on the installation of the ATMS. The necessary funding for operations and maintenance was left to the participating agencies. Most of the agencies faced serious difficulties getting the needed additional support to operate their systems. The City of Atlanta and GDOT both entered the program without assurances of permanent funded staff positions to operate and maintain the system even though operations agreements were signed. GDOT was able to create and fund 24 permanent staff positions early in the program, which was later expanded to a total of 94 staff positions. These positions could not have been created without the support of the top GDOT management. The City of Atlanta tackled a tough political battle in creating its ATMS staff positions. The City faced a variety of other issues that, initially, had a higher priority in the eyes of the Mayor and Council. Eventually (just after the close of the Olympic Games), two new positions were created and funded to operate and help maintain the City's traffic signal control and ATMS components.

At least three of the five counties are relying on existing staff to operate and help maintain their ATMS systems. Some of the counties did not feel that they needed extra staff. Others, such as Clayton County, have realigned staff duties to allow adequate time for their ATMS needs. MARTA had thought that its current staff would be able to handle the needs of the ITS MARTA '96 program. However, it found that, even though the staff was highly proficient in radio and other systems operation and maintenance, they needed to add to these skills to meet the special needs of the APTS components such as AVL and APC. There will be a need to train staff in these areas on an on-going basis. All of the ATMS partner agencies agree that the more time available to devote to ATMS operations, the more efficient the on-street operations. All of the agencies believe that they have at least the minimum required staff hours assigned to the ATMS to ensure proper operations. At the time of the interview (Fall 1996), GDOT indicated that it was staffed at a minimum engineering level, particularly for engineers who understood the system software. GDOT hoped to continue to add new staff positions in the future.

During the same interviews, agency staff all noted that it was difficult to find personnel with the appropriate qualifications to staff the ATMS system. They also noted that, even if they were able to find qualified personnel, they were unable to provide salaries that equaled those available in private industry. The agencies recognized that it was most difficult to attract and retain capable systems and software engineers. Many agencies planned to rely on contract services to meet their needs, if unable to retain the proper staff.

The ATMS partnership has agreed to pool resources to maintain the common elements of the ATMS. They have yet to clearly define how they will fund and manage system maintenance. Concepts they are pursuing include creating escrow accounts to pool funds and to collectively purchase materials. Some of the difficulties of creating a system such as this relate to the need for agencies to commit to a long-range funding stream to ensure participation. Many transportation agencies find it difficult to make such commitments.

Some of the difficulties in funding staff for operations and maintenance arose because these needs were not clearly understood and costs were not assigned to them until late in the NAVIGATOR program development. One of the consultant's tasks was to develop operations, maintenance guidelines, and budgets. For some agencies, since the details of the needs were not known until late in the ITS development process, the process of bringing on staff to meet those needs was not begun until that time.

4.3.3.2 Summary of Funding Operations and Maintenance Staff

16. The proportion of life-cycle costs, including cost to deploy devoted to operations and maintenance, are higher for ITS than for traditional transportation projects. Thus, operations and maintenance funding is even more important to ITS than to traditional transportation projects.
17. Even if adequate staff are available to support ITS operations and maintenance, they may require initial, and on-going training in specialized ITS skills. This initial training could consume considerable resources and could take longer than expected.
18. Difficulties recruiting, paying competitive salaries, and retaining staff have led agencies to use outside operations and maintenance service providers.
19. Agency staffing policies are often not flexible enough to allow agencies to readily create the specialized staff positions required for ITS operations and maintenance. The process often requires political and top management support.
20. A regionally integrated ATMS may benefit from regionally coordinated operations and maintenance. However, the long-range funding commitments necessary to create a coordinated funding pool are difficult to obtain.
21. An earlier understanding of the staff needs for operations and maintenance may have helped agencies create and fund staff positions (if needed).

4.3.4 Procuring Consultants/Contractors

Transportation agencies have several types of procurement processes available to them. The process used depends on what is being procured. At the local agencies, typical categories for procurement include:

- **Professional Services:** Services that require professional licenses in the State including many types of engineers, architects, ITS consultants and surveyors.
- **Non-Professional Services:** Services that do not require professional licenses such as landscape maintenance, trash collection, ATMS software development, and provision of computer training.
- **Goods:** Used to purchase goods directly such as desks, aggregate, concrete pipe, traffic surveillance systems, controllers, etc., or (typically at transit agencies) systems such as radio systems or fare collection systems.
- **Construction:** Used to procure contractor services for infrastructure construction, including roads, bridges, TMC buildings, and offices.

Different laws and policies govern each procurement category. The procurement categories were developed for traditional transportation procurements—either infrastructure or systems. In a traditional infrastructure project, professional service agreements are used to retain professional engineers to create construction bid documents including the plans, specifications and cost and quantity estimates (PS&E). Professional services are usually procured on the basis of qualifications, with cost negotiated. Construction contracts are typically procured as low-bid, with the exception of force accounts.

Most traditional transit systems, such as radio systems or fare collection systems, consist of off-the-shelf hardware and software. The installation of these types of traditional systems is fairly standard, modified to fit the particular needs and conditions found. These systems are usually procured using non-professional service or goods contracts, depending on the need for tailoring the system to the conditions.

If a road agency needs to install a complex radio or traffic control room, it is typically procured using the same processes as are used for infrastructure. A professional services contract is used for design, and detailed plans, specifications, and estimates are developed. The construction contract is procured as any other infrastructure construction contract would be.

Transportation agencies that have procured ITS services have attempted to fit the procurement needs of ITS into the structure for traditional transportation infrastructure and systems procurements with mixed success. The success has depended on the ability to describe the work from both a design and a construction standpoint. Agencies have been most successful using traditional procurement methods for the design and construction of ITS field devices, and the procurement of systems where the majority of components are off the shelf. Field device and traditional infrastructure PS&Es are similar. The plans can readily show the location and installation details for both types of work. The discussion of field device and system procurement is found in the section on Design in this report.

ITS systems that consist primarily of off-the shelf components, such as interconnected traffic signal control systems and AVL radio systems, have also been successfully procured using procurement rules developed for traditional transportation systems. Again, it is possible to adequately describe these types of systems because performance and material specifications are available for them.

Control systems are created to perform specialized, integrated functions. Each transportation agency has different requirements and each control system is unique. Specialized software and hardware configurations are developed for each system. These types of systems are not off the shelf, and performance and material specifications are not available for them. Using procurement methods designed for typical transportation systems has been shown to create difficulties. Even though system functions can be defined, the hardware and software options to perform these functions are very difficult to describe. There are many options, technology is currently advancing at a fast rate, and new options continually become available. It is in the transportation agency's interest to install the most current technology, because funds to upgrade or replace systems are difficult to obtain. This provides incentive for transportation agencies to defer final decisions on control system technology as long as possible, extending into the system implementation period. Thus, not only are control systems for ATMS difficult to specify, but also the specifications can become obsolete during the implementation period. New contracting methods have been developed more recently by the FHWA to address many of these issues (e.g., design/build and system manager procurement methods). GDOT used the system manager method under a professional services contract.

The following sections describe the NAVIGATOR experience with consultant selection and contracting. The issues related to developing field device, ITS systems and control systems specifications are discussed in the Design section that follows.

4.3.4.1 <u>The NAVIGATOR Experience Procuring Consultants/Contractors</u>

GDOT chose to procure services to design and implement the Atlanta ATMS using the procedures developed for professional services. Under these procurement methods, GDOT could (and did) pursue a two-step procedure, advertising first for qualifications, identifying qualified firms and then requesting proposals from the pre-qualified firms; or they could advertise for qualifications and proposals in one step. GDOT chose the two-step process. The advantage of pre-qualifying firms is that it reduces the workload during consultant selection by reducing the number of eligible consulting firms.

Reviewing proposals is a much more time-consuming process than reviewing qualifications packages. In addition, GDOT was scheduled to tour several West Coast ATMSs, and it wanted to defer completion of the RFP until after the tour.

The consultant pre-qualification process began with a request for qualifications (RFQ) advertisement placed by GDOT in February 1992. Qualifications were due in April of 1992, and a list of 12 prequalified firms was announced in May 1992. The complete RFQ process took 3 months. There was a 2-month period between the announcement of the qualified firms and RFP issuance. Much of this time was spent by GDOT in refining the scope of services, based on information it gathered in the February tour of West Coast ATMSs.

The RFP was sent to the pre-qualified consultants on July 1, 1992, with responses due on September 1, 1992. On September 29, 1992, TRW was deemed best qualified and negotiations began. GDOT and TRW signed their contract on January 25, 1993. Much of the negotiation focused on structuring an agreement that was flexible enough to allow the process to discover what the design would be, while rigid enough to conform to GDOT contract requirements for detailed scopes of services.

GDOT has a long and successful history of bringing on consultants to design traditional road and bridge works. However, the contract mechanism used for projects that can be clearly scoped and divided into design and construction phases was not appropriate to the Atlanta ATMS. First, the complete scope of work was not yet determined. In fact, developing the scope of work was one of the first needs of the project. With the assistance of FHWA, GDOT chose to use the Systems Manager contracting procedure, which had just been developed by FHWA. However, the State-level policies and standards that had been developed in the past were not easily modified to meet the needs of a Systems Manager contract. Issues included the ability to define in detail the complete scope of work and procurement of hardware needed for system development.

The Contracting group at GDOT required a scope of work that it deemed complete and of adequate detail prior to contract signing. The Contracts group had not adopted more flexible contract instruments, such as Task Order agreements, which have been used at several DOTs for projects of the nature of the Atlanta ATMS. Task Order agreements allow a specific outcome and budget to be specified. Tasks are developed as the contract proceeds, and a clearer understanding of the overall needs is gained. Each task is assigned a portion of the overall budget when the task can be clearly scoped and estimated. A typical first Task Order for a project such as the Atlanta ATMS would be the Concept Plan, which would allow for following Task Orders for the specific design elements to be developed. Although GDOT Traffic Engineering was able to provide a scope of work that clearly defined needed outcomes and most of the work elements, this was generally unsatisfactory to the GDOT Contracts group. GDOT

Traffic Engineering attempted without success to persuade the GDOT Contracts group to use such a contract vehicle.

Several months were lost as GDOT tried to work out a contracting method to bring the consultant team on board. Finally a compromise contract format was adopted. The schedule pressure of the Olympic Games led to all parties compromising on a solution. GDOT Contracts felt that the scope was not clear enough, and GDOT Traffic Engineering and the consultant team felt that the contract was not flexible enough to allow the "discovery" process innate to ATMS programs.

The nature of the control system, as described above, made it difficult to create a tight scope of work. Lacking a flexible contract mechanism, GDOT tried to use its standard consultant agreement and contract amendments. Amendments were to be used to further define the scope when the nature of the control system became more clear.

GDOT did use contract amendments, but these mechanisms are usually meant for additional work as opposed to work that is assumed to be included but cannot be clearly spelled out until other work is completed. GDOT was discouraged from using the amendment procedure as often as it would have liked for several reasons. There was a set of rules in place at GDOT that did not allow amendments over a certain dollar amount. GDOT spent some months reviewing this rule and deemed it not applicable to the ATMS consultant work. Also, creating and processing amendments was time consuming for the GDOT Traffic Engineering group responsible for managing the work. Because of this, there was incentive to create as few contract amendments as possible. The amendment process was not flexible enough for the needs of the control system. GDOT did process a few amendments, particularly when the scope of work changed drastically. However, it developed and used a more flexible process of realigning budget with tasks (internal to the consultant contract) as specific task needs unfolded and were modified.

MARTA performed two procurements for its ITS program. It used a professional services process to procure technical and program management assistance. It used the procurement process for goods to implement the systems.

MARTA also negotiated with MCI a non-exclusive right of Public/Private Partnership agreement for fiber optic cable installation. MARTA provided right-of-way and conduit for fiber optic cable from the Lindberg Station to the I-85 bridge, and MCI agreed to make lease payments and to provide MARTA with 36 strands of fiber optic cable. The communication link from MARTA to the ATMS GDOT TMC used seven of these strands.

Several projects typical to transit systems, such as radio systems and fare collection systems, follow a system implementation process similar to ITS systems.

Therefore, MARTA and FTA were experienced in awarding and managing system implementations. MARTA awarded two "goods" contracts to develop, furnish, deploy, and test the ITS MARTA '96 project systems, and one consultant contract to provide program assistance. The goods contracts were procured as fixed-cost engineer, furnish, install, and test (EFIT). MARTA believes that the EFIT concept would have worked better if the contracts were not fixed price. EFIT work includes a design element in which final costs are developed. With a fixed price, the ability to select among options is constrained by the cost. This is an acceptable practice for many more standard systems, but since this involved technologies new to MARTA, the lack of flexibility over-constrained the work.

The EFIT concept was also successfully used by GDOT. Construction contracts were let to engineer, furnish, install and test the hardware and software for the Atlanta and county TCCs. These were also low-bid contracts, but GDOT did not express the same concern as MARTA in combining fixed cost with EFIT work. This was perhaps because the level of design and specification provided in the bid documents for GDOT's EFIT left somewhat less actual engineering work to the contractor than in MARTA's case.

MARTA typically budgets a fixed percentage of its project costs for outside program management support and continued this practice for the implementation of the ITS MARTA '96 project. MARTA awarded a consulting contract to provide overall project management and quality control for the ITS program. The services were explicitly called out in a line item in the grant agreement as grant administration, engineering and design review, and program management.

The systems installed by MARTA, although fairly new to the transportation community, were not as complex as GDOT's control system. They were essentially off-the-shelf, proprietary components with included hardware/software control systems. In this way, these systems were very similar to those MARTA had procured in the past (e.g., radio and fare collection systems), and the goods procurement process was suitable. The unique element of the ITS MARTA '96 program involved installing the control systems in the pre-existing TIC. Design for the installation of MARTA's control system components was provided by GDOT's consultant (under contract to MARTA). The MARTA TIC uses the same software and has the same capabilities as the counties' and City of Atlanta's control centers.

4.3.4.2 <u>Summary of Procuring Consultants/Contractors</u>

22. The complete scope of work for an ITS program, such as NAVIGATOR, cannot be defined until after the system concept and functional requirements are developed.
23. Procurement processes developed for traditional transportation programs are not well suited to complex ITS programs, particularly the software and systems integration portion of the contracts.
24. Transit agencies have procured systems in the past; they have developed procurement policies and guidelines appropriate to ITS systems needs. Because of this, transit agencies' FTA procurement guidelines are more flexible when procuring technology-based systems than those of road agencies. Road agencies are less experienced with system procurements and often do not have appropriate contracting mechanisms.
25. Using fixed-price contracts for ITS systems work may constrain the program because the scope is hard to clearly define up front and the decisions made during the system design portion of the work may affect the overall cost.

4.4 DESIGN

This section describes the issues related to design of ITS field devices encountered in typical transportation agencies. Design is the process that results in a description of what is to be built or installed. This section discusses program management and technical issues related to design.

In traditional transportation infrastructure projects, a complete contract document—the PS&E—is prepared before the infrastructure is constructed. Transportation agencies have developed processes to manage consultants developing such design documents. These include mechanisms for tracking the project cost and schedule, ensuring that the design meets appropriate standards, and for tracking major changes to the project design. For example, monthly progress reports with standard reporting requirements are provided by the consultant. Design manuals and standard plans have been developed that include standards for a variety of infrastructure needs including roads, bridges, and drainage. Major plan changes are tracked and noted on the drawings. Design of traditional transportation infrastructure relies on such pre-approved standards. At road agencies, the engineers who manage consultant work are expert in the design of traditional infrastructure, and are trained in using the standard guidelines, and methods to do so. Transit agencies may rely on outside consultants, who are experts in transit infrastructure and the standards and requirements that apply to transit infrastructure design, to perform the task of managing infrastructure design performed by another consultant. It is not typical for road agencies to bring on outside assistance to manage other outside consultants.

Similar conditions exist for traditional transit systems, but transit systems are typically procured rather than designed. Since transit systems have been around for much longer than highway-based ITS systems, they are better understood and they have more "precedence" on hand. Even though these systems are "procured" rather than "designed from scratch," they require extensive data gathering, system specifications development, and systems integration, which consume considerable resources of the transit agency. Still, the presence of information and data from several "peer agencies" worldwide with this experience makes for quicker development times. Hence, the transit agency is typically proficient in the system design, and manages outside contractors itself, or other outside help is brought in to manage the other outside contractors. Again, it is not typical for road agencies to bring on outside assistance to manage other outside consultants. Standard practices and procedures have been developed to guide procurement of traditional transportation systems.

ITS projects are new to many transportation agencies. There are few standard practices and procedures available to apply to complex ITS programs, particularly programs involving the implementation of a control system. The design of field devices and procurement of off-the-shelf systems can be managed using the standard processes and procedures created for traditional transportation work. However, the design of a control system requires new processes and procedures, because it involves work outside that found at most road agencies including software development, hardware selection, and documentation of system hardware and software.

4.4.1 Interagency Coordination During the Design Phase

As described in the discussion of interagency coordination for Early Program Definition, ITS programs that are regional and integrated among several agencies require extensive interagency coordination. Such ITS programs are based on daily interactions between agencies that result in information sharing or changes to on-street operations to improve traffic flow. As traffic flows change over time, so will the interagency coordinated response.

Developing coordinated operations plans is part of the design phase for an ITS program. The chosen operational parameters will influence the selection of field devices, the functionality of the control system, and the hardware and software used to provide the control system functionality. Therefore, the ITS design phase requires extensive multi-agency decision-making regarding all components of the ATMS. Traditional transportation projects do not require such intense interaction during the design phase.

For traditional transportation projects, the largest amount of interagency coordination usually occurs before design, when regional decisions regarding transportation needs are being made. During design, most projects are managed independently by a single agency that is responsible for the final design and operating decisions. A higher level of interagency coordination may occur for large projects that affect multiple agencies. In those cases, the coordination process is usually pre-defined by the processes developed for Environmental Assessments or Major Investment Studies. Both of these processes provide a structure for eliciting comments from the public and affected agencies. Structure is also provided by the availability of design standards for transportation infrastructure projects that limit the range of options available to apply to the design.

Thus, ITS projects differ from traditional transportation works in the conduct of interagency coordination during the design phase in three ways:

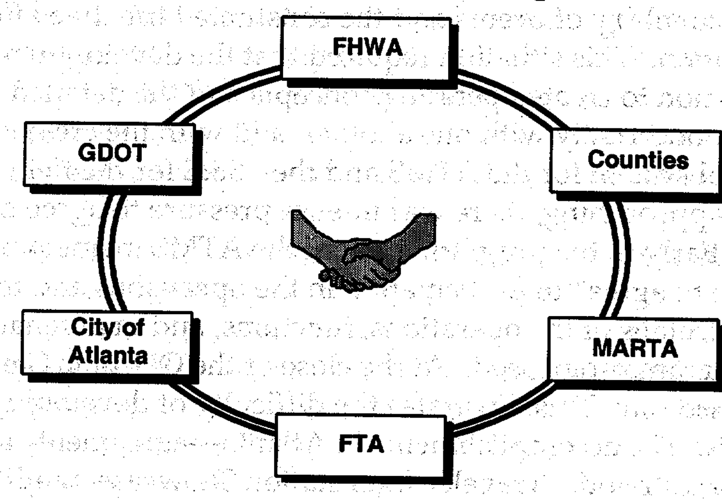
- **Development of Operating Concepts:** The operating concepts can affect traffic flows to the extent that the decisions cannot be made at staff level, but require the issues to be discussed by the local agency political body. This can be very time consuming. In addition, the operating concepts must consider both near-term and long-term operations. Some operating concepts such as traffic diversion plans to manage incident queues may not be implementable in the near term, but the ATMS partners may agree to include the capability for the future.
- **Technical Needs:** The technical decisions in a regionally coordinated ATMS are of much greater detail than those for a traditional transportation design. They involve field device selections, communications platforms and equipment, and the design of the ATMS operator interfaces. There is a variety of choices available, and there are few standards and little guidance for decision-making available. Traditional transportation project decisions are generally higher-level decisions related to location and geometric details of roads or transit operating parameters. The details to implement these higher-level decisions are typically guided by pre-approved standards. Thus, little discussion is needed regarding detailed components of traditional transportation projects.
- **Coordination Structure:** There is currently no typical structure, nor are there guidelines for decision-making for ITS programs. Traditional transportation projects involving more than one jurisdiction usually require only minimal interaction, and the issues are usually clear and straightforward. For example, for a local road expansion that spans multiple jurisdictions, the agencies must coordinate on such issues as increased traffic flows and safety. In a similar ITS case, a message provided to motorists at a particular freeway location could radically change traffic flows in another jurisdiction almost instantaneously. The ability to react and make decisions in real time has a significant bearing on the deployment and operation of an ITS. The full benefit of the deployment will not be realized unless these and similar issues are foreseen and settled prior to deployment.

4.4.1.1 NAVIGATOR Experience With Interagency Coordination During Design

In Atlanta, the chronology of events and the constricted timeline affected interagency coordination. This situation required that the development of the interagency coordination to create operating concepts and the detailed technical design be done essentially concurrently with one another, and with the creation of plans to implement the control system for the ATMS and the PS&E for the field devices. With the Olympic Games approaching, there was intense pressure to agree on basic operating concepts. Early in the program, each of the ATMS member agencies signed agreements to "agree to agree" to participation in the operations and maintenance of the regional ATMS. Details of the operations, functions, and maintenance were to be developed as the program progressed. At the close of the Olympic Games, these details were still being worked out. This illustrates the difficulty of developing consensus on operating parameters. The accomplishments in Atlanta—agreements to share incident data, creation of the multimodal Traveler Information Showcase, modifications to agency tow agreements, and others—were significant in that they are the first attempts by these agencies to work in a coordinated fashion to achieve common goals.

This section focuses on the operating agency relationships, as they are most closely related to the program design. The discussion is not a comprehensive list of all the agencies that were included in ATMS and Olympic Games coordination (e.g., GEMA, ACOG, and others). The regional ATMS concept required extensive interagency coordination, in particular among the operating agencies. FTA and FHWA served in their normal oversight and assistance roles, although they were more active than is typical because of the technical assistance necessitated by the ITS work. The regional ATMS operating agencies are MARTA, the City of Atlanta, GDOT, and the five counties—Cobb, Clayton, Fulton, Gwinnett, and DeKalb. Figure 4-1 shows the interagency relationships. All agencies involved in the development cooperated with every other agency to a greater or lesser extent depending on the level of coordination required between them.

FIGURE 4-1
Interagency Relationships



In addition to these relationships, less direct interagency coordination involving ARC, the ACOG, and the emergency responders (police and fire) is described. Although the FHWA, and FTA also coordinated on the NAVIGATOR program, this relationship was similar to their normal operations and is not included in the discussion below.

GDOT-City of Atlanta: These two agencies were the first partners in the ATMS program. The City of Atlanta had developed its own city wide ATMS concept in 1989, just before the Olympic Games bid was won. GDOT's early concept, developed in 1990, included a regional ATMS to improve State facilities operations. The agencies joined together in the request for Federal-aid funding, which was provided in the form of a line item in the ISTEA legislation. After the funding was provided, the two agencies collaboratively developed the regional ATMS concept to include the five counties and transit. GDOT took the role of program lead because the City of Atlanta felt it did not have adequate resources to manage a regional effort, and because the scope of the work included heavy investment in GDOT facilities such as the TMC and the communications backbone.

These two agencies worked well together, combining the City of Atlanta's ATMS concept with the GDOT regional ATMS concept and mustering much needed political support. The agencies had separately developed commitments to deploying ITS in the region. They each supported the program independently, and worked together toward common goals.

GDOT and Atlanta had not signed an interagency agreement regarding the detailed system operations and maintenance before the system was installed. Neither party had adequate resources to develop such agreements during the period leading up to the Olympic Games. In addition, these agreements required that the complete system functional and communications system designs be available to describe the operating and maintenance needs of the system. These designs were not complete until late in the design and implementation process. The City of Atlanta staff were therefore unable to communicate the costs associated with operating and maintaining the system to the City Council. City staff were able to get council approval of an "agreement to agree" about future operational and maintenance needs. This agreement also officially supported the concept of the City of Atlanta's participation in the regional ATMS.

GDOT-Counties: Unlike the relationship between GDOT and the City of Atlanta, the relationship between GDOT and each of the five counties did not begin with shared goals. The counties had not yet contemplated ATMS applications (beyond interconnected traffic signal systems), much less a regionally integrated ATMS. Although traffic congestion in the counties did cross jurisdictional lines, interagency coordination to address a common issue was needed only occasionally—not on a day-to-day, on-going basis. Essentially, GDOT had to promote the benefits of the regional ATMS concept to the counties. The investment for completion of all aspects of the county TCCs was also borne completely by GDOT. The counties provided some technical support and operational resources.

The regional ATMS concept included the potential for remote control of county traffic signal systems at the GDOT TMC, and the capability, at the TMC (and to a lesser extent at the TCCs), to divert traffic from congested facilities to less congested ones. On the basis of comments received in the focus group sessions, the counties felt that they were being approached by a more "powerful" agency that seemed to be asking for control of some decisions normally made at the county level. The counties did not feel that, even with the traffic pressures expected during Olympic Games, that they could convince their Council members that traffic diversions would benefit their county's citizens. The county traffic engineers generally agreed that the integrated incident management software would be a useful interagency communications tool. The counties eventually were persuaded by GDOT to join the regional ATMS program to be prepared for Olympic Games traffic demands. Two of the five counties had already made a commitment to ITS and understood the benefits. This commitment was in part due to the experience and expertise of the individual county traffic engineers. Other counties had little experience even in traffic signal operations and were much less committed to a regional ATMS concept. All of the counties did agree to sign on to the program, but the level of commitment varied, and was largely based on the attitudes the traffic engineers brought with them from the beginning of the program.

One additional difficulty identified by the counties relates to the ATMS decision-making process. There were more than 10 committees developed related to the ATMS and Olympic Games readiness. The counties had insufficient staff to attend all of these committee meetings. It was typical for the counties to assign the same staff person to all of the committees. The meetings most often attended by county representatives were the steering committee meetings, where higher level decisions were made.

Barriers also arose because GDOT's and the county DOTs' goals were not matched. While GDOT was ready to move into the ITS arena, some of the county DOTs felt that they had many other pressing transportation issues, such as maintenance and operations of their existing systems, that they had to address before adopting an ITS solution. In addition, there was a sense that some personnel at the agencies were resistant to change, including changing to add ITS technologies.

As with the City of Atlanta, the counties officially "agreed to agree," but did not work out the operational, maintenance, and other issues that would dictate system design, functionality, and each agency's budget needs. As stated before, the information and personnel resources were unavailable before the Games to investigate these issues. The counties and GDOT have yet to complete the details of interagency operations and maintenance agreements.

Even with the barriers described above, the ATMS provided a forum for interagency coordination that had not existed before, and accelerated interagency cooperation and coordination. The Olympic Games experience allowed most of the ATMS partners a chance to evaluate the usefulness and potential of the regional ATMS. The overall experience was positive, and the ATMS partners are committed to continued coordination.

GDOT-MARTA: Although transit was included in the early concepts (developed by the City of Atlanta and GDOT) for the regional ATMS, transit was not included in the program consultant's scope of work. In 1993, the FTA proposed to MARTA that they participate in the regional ITS system to showcase transit ITS capabilities. MARTA and GDOT then began formal coordination to connect MARTA to the regional ATMS. Informal coordination between GDOT and MARTA had been on-going before this time, but MARTA was unable to assign many resources to the regional ATMS work until its own funding needs were met. Even though MARTA was brought into the program fairly late, it was connected to the ATMS system before some of the counties. This was because MARTA made a significant commitment to the ATMS, the TIS, and the Kiosk project interconnections with their systems because of its appreciation of the sizable benefits that could be realized from these to help them serve the high transit demands expected during the Olympic Games.

MARTA's experience showed how quickly an agency can act to join the regional ATMS, and illustrated that agency "buy-in" is critical to the deployment process. MARTA's experience can be contrasted somewhat to that of the counties. The counties did not all "buy in" on their own to the regional concept. They could not manage the design or control the funds to design and install their TCCs and communications links to the system because they did not have the resources to devote to it. They did manage work related to traffic signal upgrades, CMS installation on arterials, and local field communications. Like the City of Atlanta and the counties, GDOT and MARTA have yet to complete detailed interagency operations and maintenance plans.

ARC: ARC was an early participant in the ATMS planning, coordinating the regional Incident Management Task Force even before the regional ATMS was conceived. ARC moderated meetings with representatives from the City of Atlanta, GDOT, and the five counties in which incident management needs were collaboratively identified and prioritized. The committees decisions were used to program moneys for incident management including funds for GDOT HERO vehicles, and push bumpers for enforcement vehicles.

As noted in Section 3, the ATMS Steering Committee was formed and led by GDOT in 1993, which took over the incident management activities coordinated by ARC. Although the Steering Committee and its subcommittees were essentially a collaborative forum, GDOT retained final decision control. ARC served as an advisory member of the ATMS Steering Committee.

Input from the focus group sessions indicated that some of the Atlanta-area agency transportation staff believed that, to deploy, operate, and manage a regional ATMS, there must be a lead agency in charge, empowered with final decision-making authority, and that it possess strong political support. Decisions by committee can be very time consuming. Other transportation agencies in the Atlanta region, usually those with fewer staff, monetary, and technical resources, felt that too many decisions rested solely in GDOT's hands, and that their specific needs were not being considered. On the basis of the City of Atlanta's and the county's input to focus group discussions, ARC is generally viewed as a strong moderator and coordinator of multi-agency issues. The counties, and City of Atlanta felt that ARC would have been an appropriate agency to coordinate the complete regional ATMS program; however, it was seen as too weak in ITS technical skills to be effective. It was suggested that, if ARC added staff skilled in ITS technical issues, ARC could have been an effective coordinator of the complete regional ATMS program from planning through design issues.

Emergency responders: Before the regional ATMS program, it was very difficult for GDOT to coordinate with the police and fire department personnel responsible for managing traffic incidents in the region. These agencies' missions include many other functions and most did not have separate traffic units. The Atlanta region is structured such that the jurisdictional boundaries include the highways—the Georgia State Patrol (GSP) enforces only rural State roads. Because there were so many emergency response agencies potentially affected by the regional ATMS and the incident management capabilities it provided, bringing all the police and fire personnel into the program was important. GDOT focused first on coordinating with the Atlanta Police Department (APD). GDOT and the APD had forged a relationship earlier during the design and deployment of accident investigation sites along roadways, and the introduction of GDOT HERO vehicles on freeways in the Atlanta region. APD was also assigned a key role in Olympic security within the City. GDOT coordinated early on with the GSP, which also had an extensive Olympic security role, including patrolling the area freeways during the Games.

Bringing the police agencies into the program was difficult because some police agencies felt that their police powers were being encroached upon. They felt that the ATMS placed GDOT in a central role for incident management—a role which they believed was theirs to ensure public safety. However, once some of the ATMS functions were in place and working, the police were better able to understand their usefulness, and how GDOT, the City of Atlanta, the APD, and GSP could together use the ATMS to better communicate and coordinate. The result was that GSP troopers were housed in the TMC during the games, using it as a central communications point. The APD created a separate command center for the Games, the Atlanta Traffic Operations Center (ATOC), in City Hall East. ATOC was provided with the same video image controls as any of the TCCs, and was used extensively by the APD during the games. ATOC was a temporary set-up for the Games only, but the Atlanta police are hopeful that a permanent ATOC will be created.

Attempts were made to integrate incident management operations with other regional police and fire departments. However, there was little interest from them, and GDOT did not have enough resources to make a concerted effort. ARC had begun coordinating with local police and fire departments via the Incident Management Task Force, but found them disinterested, rarely attending meetings.

It is likely that police and fire departments missions and resources did not allow them to become heavily involved with the ATMS incident management issues. In addition, they often cannot readily understand how the DOTs can be of use to them in managing incidents. When the video images were brought on line, and the police departments were shown the capabilities not only of the video but the IMS, they could better understand how DOTs and police could work together to improve incident management via the ATMS. The DeKalb 911 operations center was informed by the county Traffic Engineer of the video capabilities of the regional ATMS. They observed the video when it came on line in DeKalb, found it valuable, and funded a passive feed of the video system into the 911 dispatch center.

4.4.1.2 Summary of Interagency Coordination During Design

26. Some agencies are more committed than others to ITS. It is a challenge to bring on those that have little pre-existing commitment to ITS concepts.
27. Comprehensive operating agreements are essential in order to achieve the full benefits of an intermodal, interjurisdictional ATMS.
28. Law enforcement and other emergency services agencies will likely realize measurable benefits from participation in integrated incident management systems. Once they are able to actually see an ATMS in action, and how it benefits their own operations, they often become highly supportive of integrating with the regional ATMS operations.

29. There is a lack of guidance to support interagency coordination and decision-making for ITS programs. Different agencies often support different decision-making approaches.

4.4.2 Field Devices

The field devices provide information that is processed by the control system. The location and capabilities of field devices influence the functionality of the ATMS. For example, the amount of detectorization available on a facility will influence the control system's capability to automatically detect traffic speeds and incidents. The number and position of CMSs will influence the ATMS system functionality in the choice of responses to incidents. When developing an ATMS concept, the field devices cannot be separated from the planned functionality.

The first step in the development of an ITS program such as NAVIGATOR is the creation of a Concept Plan. This plan evaluates how ITS devices and operations will address needs, including costs and benefits of alternatives. It includes preliminary plans showing the number and location of field devices, discussions of alternative field devices that may provide similar benefits, alternative communications systems and locations of any communication system components, and a description of the functions of the control system. The Concept Plan also includes the locations of TCCs (and TMCs and TICs). It outlines how the agency wishes to operate in concert with the field devices and with other agencies.

4.4.2.1 NAVIGATOR Experience with Design of Field Devices

Field device design for NAVIGATOR was based on the Concept Plan. The Concept Plan was influenced by the anticipated needs of the Olympic Games, but focused on the long-range needs for the region. The Concept Plan developed for the NAVIGATOR Program included an analysis based on current and projected non-Olympics traffic conditions. The projections for the Olympic Games were not available, and needs had to be surmised on the basis of locations of Olympic venues and preliminary gross attendance estimates. There was no guidance available to GDOT to help it direct its consultant in the development of the Concept Plan. There was no information on what should or could be included in a Concept Plan for an ATMS. This lack of information and guidance can be contrasted with the amount of guidance available for what should and could be included in, for example, a Design Report for a road project. There are manuals available with examples and guidance for such Design Reports.

Since the Concept Plan did not address alternative configurations of field devices or technologies, alternatives analysis was not included. Since it was presumed that the systems were necessary to manage the Olympic Games needs, there was no cost/benefit analysis. Cost/benefit analyses are important for many reasons. First, they allow agencies to describe system benefits to the public and decision-makers. Second, they allow for the evaluation of alternative approaches to achieve the same benefits. Third, cost/benefit analyses can be used to establish thresholds or guidelines for installation. When portions of the system had to be selected for deferred implementation after the Games, GDOT did not have a cost/benefit tool or data to assist with that decision. The time constraint imposed by the Olympic Games was an overriding factor that necessarily influenced GDOT's decisions. Time had to be the foremost consideration in decision-making, with due consideration for cost.

Because the NAVIGATOR Concept Plan focused on ITS devices and functions, it did not include scenarios that integrated ITS devices with other, non-ITS transportation management tools. For example, the Concept Plan did not include a formal analysis of the deployment of GDOT HEROs in light of the capabilities of the ATMS. The GDOT HEROs deployment plan was developed in meetings involving GDOT and FHWA where the concept of GDOT HEROs as the on-street implementation of the pro-active incident management concept was developed. This deployment decision resulted in a highly successful operation. GDOT HERO deployment may have been further optimized if a more rigorous analysis had been performed that outlined targets for incident detection and clearance, considered accident rates and traffic volumes on a freeway segment-by-segment basis, and considered GDOT HEROs as GDOT's "eyes" on freeway segments where cameras were not to be installed in Phase I. The goal of such an analysis would have been to maximize the overall reduction in delays due to incidents on the urban freeway network.

The ATMS Concept Plan was finalized and received formal approval from FHWA. Individual issues raised in the Concept Plan were addressed, and approval of PS&E for field devices constituted final approval. This process was successful, but resulted in some difficulties. Clearly, many of these difficulties could have been overcome if better details were available in the concept stage and if the changes to the Concept Plan could have thus been minimized. The fiber optic communications trunk was one of the first elements to be designed. The TMC, TCC, and TIC locations were known, the trunk location was known, and there was reasonable consensus on the location, number, and type of field devices. To expedite construction, the communications trunk was divided into four main sections (and several less substantial subsections) and contracts were let as soon as each section's PS&E was completed. The fiber assignment was not performed until the construction phase because the field devices were not finalized until then. A separate systems integration contract was developed to connect the field devices, the TCCs, and the hubs. End-to-end testing was difficult because of the multiple contracts for trunk installation and the separate contract for the devices, TCCs, and hub connections. If testing uncovered any problems, it was very difficult to assign responsibility to any one of the multiple contractors since no single one was responsible for the complete system. Of course, none of the contractors was eager to take on accountability for deficiencies themselves if they were able to implicate other contractors.

Agencies were constrained to use their traditional low-bid process to procure the field devices. Often, ITS field devices can be specified as easily as most traditional infrastructure elements, because the field devices are off-the-shelf items for which performance and material specifications are available. However, just as often, it is difficult to develop "tight" specifications for ITS field devices because the devices are complex, continuously evolving, and the specifications must cover multiple performance and material specifications. There also has been some difficulty with ITS field devices not providing the performance desired even though they meet the technical specifications. In Atlanta, specifications were developed with the intent of procuring those devices that would provide only the needed functionality. However, there were instances when devices proposed by the contractor met the letter of the specifications, but did not perform as needed. Usually, these particular devices were not known to GDOT or their consultant when writing the specification. This made it difficult to design a specification that excluded these devices.

This issue illustrates the problems in procuring complex ITS systems on the basis of low-bid contracting. There is no incentive to the contractor to purchase equipment that would meet the true intent of the specifications if a lower cost item that meets the letter of the specifications is available. The use of proprietary specifications, with appropriate justification, has helped remedy this issue. Other methods are being used including requiring that the devices be tested in the field before they are accepted.

In a few instances, GDOT got FHWA approval to use proprietary specifications to ensure proper device performance. GDOT used proper justification and submitted support for sole source specifications. Based on traditional procurement processes of FTA and transit agencies, the transit agencies enjoy more flexibility in procuring systems.

These issues related to proprietary specifications are not unique to ITS projects, and can arise on traditional transportation projects as well. However, they are more prevalent on ITS projects because of the complexity of the systems. In addition, the need to complete the system before the Olympic Games made the resolution of such issues even more critical. Staff time was diverted to address the issues, and equipment procurement and delivery was delayed. Although technical issues were the primary reason, these other factors contributed to the lack of full camera system functionality for the Olympic Games period (the VID system was made operational in late Fall 1996).

4.4.2.2 Summary of Design of Field Devices

30. There is a lack of guidelines for the development of Concept Plans for ITS deployments. Since Concept Plans are the first step in overall ATMS deployment, they are critical to overall program success.
31. Field device implementations can generally be adapted to traditional PS&E processes. Modifications to the low-bid field device procurement process will better ensure proper field device performance and functionality.

4.4.3 Control System Implementation for the Regional ATMS

The control system is the part of the ATMS that addresses and controls the field devices, processes information sent by field devices, controls incident response, and can send information to other system controllers for a variety of uses. It consists of hardware and software, specifically designed and configured to meet the desired functional and operational needs, and to integrate the specific field devices that are part of the ATMS. The process of integrating hardware and software into a control system is defined as system implementation in this report.

4.4.3.1 NAVIGATOR Experience With Control System Implementation

In addition to the Concept Plan, another important document in the development of a control system is the Functional Specification. The Functional Specification relates to the ATMS hardware and software system that controls and addresses the field devices. The Functional Specification describes performance requirements and includes technical specifications for standards that must be followed. The Concept Plan and Functional Specification are the documents that guide the development of the control system. It is difficult to provide contractual control without Functional Specifications to direct the system implementation and a Concept Plan to direct field device and communications trunk work and to describe the operating concepts. Drafts of the Concept Plan and Functional Specifications were submitted for NAVIGATOR, but neither was finalized or approved. ATMS design is an iterative process that evolves as new information is provided in each step. The preliminary Concept Plan and Functional Specifications were used in Atlanta as the starting point for the design process. The system functional requirements were developed in a continuous series of meetings and interactively on a daily basis. Intense time constraints resulted in the need to allocate time to installing systems to meet these needs, rather than to updating the documents outlining them.

Some of the difficulty in developing the control system was a result of the unique nature of the system architecture and the field devices. Although the technology for performing many of the functions specified in the ATMS was imminent, there existed no system anywhere in the United States with the same functions as those proposed for Atlanta. These included:

- Integrated incident management and traffic signal timing control that could be used by all ATMS member agencies
- 1.5 generation 170 and 2070 signal control
- Integration with NEMA signal controller software
- Use of the UNIX platform for the complete suite of incident detection and management functions
- VID-based incident detection and traffic flow parameter measurement
- Relational GIS-based database connecting all functions

These functions required new software to be developed specifically for the Atlanta control system. Developing new software is a complex task that is difficult to complete within a constrained time frame, as was the case in Atlanta. The software developers cannot easily predict the extent or structure of the software code needed to address each new device or function. Thus, although schedules can be drawn up, projects involving new software development must be planned and managed to address uncertainties. Schedule delays due to unanticipated difficulties are common in the development of new software. In Atlanta, selecting a large number of untried functions threatened the ability to meet the time schedule. In addition, the capabilities needed to communicate with some of the field devices specified could not be developed until the field devices were delivered, which, for a majority of the field devices occurred late in the program.

GDOT staff had never undertaken a project involving the development of new software as needed for the regional ATMS. They had not developed a set of procedures to guide the development process. The consultant developed the software using a standard Department of Defense procedure that it and the defense software industry had experience applying. GDOT and the consultant agreed on using this procedure. However, since GDOT had no experience developing software, it was unsure what to expect in the process. Developing the system software was one of the most difficult challenges of the Atlanta ATMS program, including difficulty determining progress in software development, the need for multiple prototypes, and the importance of configuration management in software design.

Software development progress is very difficult to gauge, particularly for those who are not software coding experts. Software is typically developed in small, 50 to 100 line modules. Each module is tested individually for "bugs." However, the testing of the individual modules provides no indication of how well the software will meet the functional requirements. The modules are linked together into sub-routines to perform the necessary system functions and tested again for software "bugs." It is difficult to know how many modules are required to create each sub-routine, which also makes it difficult to assess progress. At this point, real data or commands can be processed within each group to determine if it performs as needed. However, if the code remains unlinked to a graphical user interface (GUI), the only indication of the software performance is the printed output from a test with real data. Although software experts are often able to visualize how the sub-routines will function as part of an overall system by reviewing the code and the results of data tests, most others cannot. The sub-routines are then integrated together and the complete system can be tested. Again, if not connected to a GUI, the user cannot easily determine if the functionality is provided.

One way to improve the ability to understand and to gauge software progress is through prototyping. The time constraints imposed on software development in Atlanta limited the amount of prototyping that could be done. It also highlighted the importance of prototyping not only to help understand the schedule, but also as a means to improve communications regarding system functionality. Prototyping can begin even before software code is written. Tools are available to build mock-ups of user screens, and the various screen functions can be walked through step by step. Alternatives can also be presented early on to help the user and software developer to communicate regarding system functions and the screen "look and feel." Software cannot be meaningfully connected to GUIs until at least the sub-routine level.

In Atlanta, most of the software system was completed before prototypes were available. Even though there had been on-going discussions between the software developers and GDOT regarding the system functions and user interface needs, verbal discussions were not enough. Until the visualization is provided via a prototype, the user cannot fully understand the direction in which the software development is proceeding. The prototype in Atlanta, although true to the verbal discussions, revealed that there are many possible interpretations of functional requirements. In addition, GDOT found in Atlanta that, until all affected departments and agencies began to use the system, many of the requirements did not emerge. This is in part because many operational procedures are unwritten, and in part because ITS was new to GDOT and the ATMS partners, and they had no past experience on which to base their requirements. After the software was put in use during the Olympic Games, much of it was reconfigured on the basis of the operators' and managers' experiences with the system.

Configuration management is a critical element of software design, particularly when software is going through quick evolution in response to user-directed changes. Again, because of the time pressure to provide a functioning ATMS, configuration management was not carefully controlled. This made it more difficult to modify the software after the Olympic Games, because there was no documented baseline from which to start. The Atlanta ATMS software was brought into configuration management after the Olympic Games. Configuration management of the system hardware was also incomplete, and was also brought under control after the games.

Hardware selection for the ATMS control was influenced by the appearance of new technologies during the development process. The hardware for the control system communications design had been selected and approved in mid-1994. In January 1995, the consultant recommended that the system communications design (the SONET ring) be changed to incorporate the latest emerging technology. The new technology provided increased bandwidth and capacity. However, the technology was so new that it had not yet been tested in any application. The Atlanta control system would be the first application of the new technology. GDOT elected to proceed, even though the decision would result in a risk that the components would not be available in time for the Olympic Games, and that they could produce systems integration difficulties. The new technology did pose some difficulties, but they have been overcome. It provided a large increase in capacity and additional redundancies. GDOT's decision was largely influenced by a concern that its system might not be able to be easily upgraded to increase communications system capacity in the future, since there are few funding sources in place that are specifically directed to ATMS upgrades.

Systems Engineering Management Plans outline the processes used to develop and integrate a complete ATMS. A plan was developed in Atlanta, but could not be used effectively to manage the complete ATMS integration because there were multiple contractors working simultaneously installing various components of the NAVIGATOR program. In addition to the ATMS contractor, other contractors were working on systems to implement the Kiosk FOT, the Traveler Information Showcase (TIS), the TCCs, ATOC, and TIC, and there were multiple field device contractors. To ensure that all elements of the work were integrated in a complete system, GDOT began weekly Systems Integration meetings.

The Systems Integration meetings were led by the ATMS Contractor and attended by GDOT, FHWA, MARTA, FTA, and all affected contractors. FHWA staff provided valuable assistance in the meetings by encouraging and facilitating communication and agreement. Since FHWA was neither a contractor nor the contracting agency (with the exception of the TIS), it was well suited to perform this role. Before the meetings were held, each of the individual contractors had been proceeding without any coordination, even though each one's work affected or was affected by another's. Each weekly meeting lasted at least 4 h. Through these meetings, the contractors were able to discuss their problems, needs, and approaches to resolution; GDOT was able to coordinate the efforts of the contractors, taking advantage of their pooled knowledge and experience. If a particular issue affected all or many of the contractors, there was no need for them all to tackle the work needed to resolve it independently. The contractors would agree on a fair division of work, and reported back with results the following week. These meetings also created a forum to agree on a common look and feel for the TIS and the ATMS, which was important to achieve ease of use for various system devices for users and to ensure the TIS could be readily integrated as a legacy system after the games. The Systems Integration meetings were highly effective and key to bringing systems on line for the Olympic Games.

4.4.3.2 Summary of Control System Implementation

32. It is difficult to gauge progress in software development. In addition, there are many difficulties in translating a non-automated process to an automated one. The program management skills needed for ITS programs that include work outside of the traditional transportation staff's expertise, such as software development, are different from the skills needed to manage consultants performing work that the transportation staff is expert in. Therefore, custom-designed and developed software can represent the highest cost and schedule risk for an ITS program.
33. Prototyping early and often is critical to software development success.
34. There are no standard guidelines in place at transportation agencies to help guide software development and mitigate risks.
35. Design and implementation of a complex control system incorporating multiple untried technologies is highly risk-prone since adequate prior experience is not available to rely upon.
36. There are no processes in place at transportation agencies to guide configuration management of control systems.
37. The funding structure for ITS programs promotes adoption of the latest technologies because there are few funds available for future technology upgrades. This may result in late changes to the control system. If there are schedule pressures, late changes may affect the ability to complete the control system within the needed time frame.
38. There is no guidance for the development of Systems Engineering Management Plans which, when well designed and followed, are critical to ensuring proper system integration.
39. To help manage and integrate multiple contracts, a Systems Integrator contract can be used. To facilitate coordination among multiple contracts, weekly meetings (with FHWA or FTA support as a facilitator) can be a highly effective tool.

4.4.4 Technical Issues Specific to NAVIGATOR

Regulatory Issues. Several regulatory issues were encountered in Atlanta including:

- The need for FAA clearances for camera poles or other potential obstructions installed on the freeway system that lay in the flight path of an airport.
- The need for FCC licenses for dedicated radio frequencies for HAR and microwave communications.

- A review of privacy laws was undertaken with respect to the right of the local agencies to use cameras. No obstacles have yet been found in the Atlanta region.
- The ownership of traffic related data that might be sold to private concerns for repackaging and broadcast to the public was investigated. The question of who owns the data remains unresolved, but has been successfully managed. To reduce concerns over freeway camera surveillance, GDOT does not record video images to tape. The only images available are live.

GIS-Based System Issues. Atlanta's regional ATMS uses a GIS-based system for a variety of functions. The GIS system is used to locate incidents and to link the incident with a library of suggested incident response plans, and for graphical control of field devices. MARTA also uses a GIS-based system to track its buses in real time and space using the AVL. Overall, the decision to use a GIS-based system provided additional functionality that was key to many system functions. It can be particularly useful in the future when new functions related to fleet management and traveler information are brought on line. Map-based ATMS is also highly user-friendly since information is presented spatially, in a plan view of the system. For example, an operator can point and click on a particular sign on the basis of its location on the map, rather than having to call it up on the basis of a locational code that bears little relationship to a map location.

GIS-based systems require maps and databases to link to the maps. Maps were available from a variety of sources for the Atlanta ATMS system, but they had to be augmented and checked for accuracy for use in the ATMS. In addition, the incident response plan library had to be developed and linked to the maps to allow for automated incident response. The library of incident response plans can become very large. MARTA had to link its bus schedules to the GIS map and augment the mapping with bus stop locations. This task took much longer than anticipated, and the complete system was not ready for the Olympic Games. The need to continually update these databases as transit schedules are updated is an on-going operations need that was not fully understood when the program began at MARTA. Despite these challenges, GDOT was able to bring the most critical portions of the GIS-based incident management software successfully on line for the Olympic Games. The incident management function of the ATMS was key to managing the games transportation demands.

Another difficulty faced in Atlanta was that there was no mature commercially available map base. Mature refers to the amount and types of information available on the maps—as the maps mature, items such as water and sewer lines, property lines, and other features are added based on market demand. There were only two commercial maps available that were state wide maps (as would be needed as the ATMS progressed beyond Phase I). These maps contained only basic information such as road and municipal border locations. The map base that contained the most detail for the City of Atlanta was selected for the ATMS, and was adopted by each ATMS partner agency for ATMS functions.

Current map technology did not allow the ATMS map base to be used for all map-based functions of each agency, although this is an overall goal for most agencies. One of the difficulties in using different map bases for different functions (e.g., for designing road plans) is that the maps are not easily translatable from one platform to another or from one software package to another. One reason is that the different map software uses different referencing systems—one may be based on coordinates and another on segments. This is a difficult translation problem for which no commercial or proprietary software existed. Specialized software must be written to allow translation. GDOT plans to develop such software in the near future.

Addition of Originally Unplanned "Peripheral" Functions. The original scope of services did not specifically identify the ADAS, Kiosk, and Atlanta TIS projects although the functions of these projects were indicated as needed system capabilities. To provide for these future, unknown needs, the system was designed to include the capability of connecting several servers (personal computers that are assigned to a specific data processing task). The capacity for servers depends on the data processing needs of the servers connected, and the processing capability of the ATMS system. If the data processing needs are small for each peripheral function, a large number of servers can be connected. If the processing needs are large, the ATMS system capacity could be reached with only a few peripheral servers connected. There were no difficulties with server capacities in Atlanta.

NEMA and 170 (or 2070) Traffic Signal System Support. Both GDOT and the City of Atlanta had independently selected the 170 signal controller as their standard, with the intent of upgrading to 2070 controllers when they became available. The basis for this decision for the City of Atlanta was the open and direct interface capabilities of the 170 controllers compared with NEMAs. GDOT had spent many years evaluating NEMA and 170 controllers, and chose 170s for a variety of reasons including the proprietary issues of NEMA systems. Any manufacturer's 170 can talk to or be interchanged with another's for the full functionality, but this is not true of NEMA controllers.

This technical decision was presented to the counties which perceived it as a directive to replace their current NEMA systems. GDOT did wish to encourage the use of 170s to improve ultimate system performance, and focused a significant portion of the regional ATMS funds towards controller replacement within the counties. However, the counties felt that they did not have the resources to replace all of their NEMA controllers. Most of the ATMS partner counties elected to pursue a controller replacement program to phase out NEMAs over several years, but some counties decided to remain all NEMA. All of the counties required a method to interface their NEMA systems with the ATMS. This was not a simple task, since the NEMA systems were proprietary and closed. There was no way to develop an interface without the NEMA manufacturer supplying confidential information about its system.

GDOT and its consultant approached NEMA suppliers to negotiate a fee to allow an open interface. However, the NEMA suppliers would not provide the information needed for an open interface with the ATMS under any conditions. Therefore, to interface with NEMA systems, the suppliers provided a "black box" that exchanged information between the NEMA systems and the regional ATMS. The difficulty with the "black box" is that it supports only the current NEMA system functions. If upgrades are introduced, they may not be able to be addressed remotely via the ATMS. Also, a second server —one for the NEMA system itself and one for the ATMS—was required at the county TCCs. With a 170 system, these functions can reside in the same server.

Highway Advisory Radio. The HAR system was subject to major airpath interference problems. Messages for broadcast are sent via hardwire to the HAR antennas. The antenna broadcast message includes a signal to activate flashing beacons on driver advisory signs. The signs advise motorists to tune into the HAR station when the beacons are flashing. The HAR system uses 10-watt antennas. The first frequency attempted was 740 AM—it was interfered with by a 5000-watt radio station antenna broadcasting at 750 AM. Next, the antennas and encoders were reconfigured to broadcast at 530 AM, which is a band reserved by the Federal Communications Commission (FCC) for traveler advisories. Multi-path reflection from a Cuban radio station interfered with this band (Cuban stations are, of course, not controlled by the U.S. FCC). In both cases the broadcast and flashing beacons were so unreliable that the system was not used. GDOT is currently exploring other options. Wireless interference is a major issue in most urban areas in the United States, particularly on the AM band. The FCC prefers to use very low or very high frequencies for traveler advisories, and has only rarely approved other AM bands for that purpose. Although some locations have found better success with FM transmissions, the FCC has not typically licensed FM band for traveler advisories. More importantly, the FCC does not specifically protect any transmission bands from interference.

4.4.4.1 Summary of Technical Issues Specific to NAVIGATOR

40. ITS programs include components that present special regulatory and technical challenges that are not found in traditional transportation programs.

4.4.5 TMC Building

Often a new building must be constructed, or an existing building modified, to house the ATMS control system. Transportation agencies (and particularly traffic engineers) rarely construct buildings other than the occasional maintenance facility or rest area. If building construction is required, it is usually the job of the group responsible for overall building management (at the State level, it is usually the General

Services Administration). As for any program outside the usual work of an agency, processes, standards, and trained staff are usually not available to manage the program. The ATMS contract scope of services also included the design and construction of the TMC building, which was to house the control system and to include GDOT and Georgia Emergency Management Administration (GEMA) offices.

4.4.5.1 NAVIGATOR Experience With the TMC Building

The original scope of services for the TMC building was very general. It did not specify size, the functions to be housed in the building, or the proposed design standards to be used. These matters were to be developed as recommendations by the consultant and presented to GDOT. GDOT's space requirements called for a four-story building at the TMC site. However, funding was available for only two stories when work began. The intent was to design a two-story building that could be expanded in the future to four stories. It was important to begin construction of the TMC building as quickly as possible to avoid delays in installing the control system. The consultant began designing a two-story building. During the design process, the funding was made available for the full four-story building, and the consultant was asked to change the design. This change took several months to finalize as the plans needed to be modified and amended to reflect the change.

Other difficulties were encountered because the consultant was unfamiliar with GDOT standards, and GDOT was unfamiliar with building design and construction standards. GDOT, as is typical at transportation agencies, had little familiarity with building construction. Several delays were introduced because GDOT engineers needed to be informed about current structural design practices (such as auger piles). In addition, the standards for building construction, including the methods of payment, are much different than those used in road construction. The consultant, acting as building construction manager, and GDOT construction needed to agree on the standards to be used and ensure that they were understood by all parties.

The consultant was unfamiliar with GDOT's practices, and was particularly uneasy when asked to use the "fronts" of the GDOT standard specification—those sections that cover the legal requirements including progress, prosecution, and payment—when it had traditionally used American Institute of Architecture (AIA) standards. Several meetings were arranged to create a hybrid GDOT/AIA document. During this process some special provisions required were accidentally omitted, because there was no single person familiar with both standards. For example, the responsibility for creating as-built drawings was not included. Despite these challenges, the TMC building was completed within time for the Olympic Games.

4.4.5.2 Summary of TMC Building

> 41. TMC building design and project management requires specialized expertise not typically found within traditional transportation agencies. Transportation agency construction standards differ from those in the building construction industry, and are difficult to adapt to building contract needs.

4.4.6 Program Management

At traditional transportation agencies, program management of typical projects is supported internally by standard processes and procedures. Standards have also been developed to guide the management of consultant and outside contractor work. These standard processes and procedures were developed to meet the needs of typical infrastructure or systems projects and include standards for design reviews, program scheduling tools, design manuals, construction manuals, contracting policies, and a variety of policies related to overall program management. These standard processes and procedures are not tailored to the management of ITS programs.

4.4.6.1 NAVIGATOR Experience With Program Management

The Atlanta Regional ATMS is a large, ambitious, and complex program. It involves diverse field devices, an extensive communications system, and a control system developed using a distributed systems architecture. Eight local agencies are connected to the regional ATMS. Twenty-nine project deliverables were included in GDOT's consultant contract. Each of the 29 deliverables was essentially a project in itself, with many other deliverables required. Managing such a complex program is a difficult task that calls for a detailed program plan. Because transportation agencies do not usually take on such complex projects, particularly complex systems engineering projects, the tools to manage them have not been developed as standards.

Although project schedules were used to help manage the work, there was no detailed program management plan. The types of schedules used are good tools for managing traditional road projects because there is more history and less uncertainty in the design of a road. The NAVIGATOR program involved much uncertainty and risk, and there was little experience to rely on. Most ITS programs require a more detailed program management plan than is used for traditional transportation programs. Such a plan provides more detail for each task, breaking them into subtasks, and identifying the dependencies and connectivities between tasks. For complex projects, this approach is important because a seemingly innocuous change or delay in one task could have unintended effects on another, seemingly unrelated task. It is impossible for a project manager to evaluate and assess each of the hundreds of tasks and task dependencies in a project such as the Atlanta ATMS without an appropriate management tool. Critical path method scheduling tools are appropriate. Other key elements of the Program Management Plan beyond the definition of tasks, schedules, and dependencies include the identification of decision points, task and decision responsibilities, coordination needs, and critical paths.

Additional management detail and tools are created for each of the major tasks involved in control system design. The program management plan defines and integrates them together in the overall program plan. For example, the software and hardware design for the control system require a Systems Engineering Management Plan (SEMP) be developed. The Program Management Plan refers to the SEMP, and indicates how the SEMP relates to other plans such as the Software Development Plan (described below) created for the project. Quality Management Plans are also referenced in the Program Management plan. The schedule and task needs outlined in each of the sub-task documents are brought together in an overall program schedule.

The Program Management Plan also includes methods for recording, incorporating, and communicating program decisions, changes, and problems. These change control methods relate to the overall program and should not be confused with Configuration Management, which is more specific to the ATMS control system development.

Program management tools specific to ITS needs were not available for NAVIGATOR. Detailed schedules were often developed for specific tasks, but the schedule tools used did not include the ability to evaluate task dependencies. Changes were made by oral or written communications between the contractor and GDOT using no standard method. Changes were often not known to the other ATMS partners unless the partner asked specifically about the task, or if the changes were discussed at the Systems Integration meetings.

Another tool not typically used at transportation agencies is a Risk Management Plan. The methodology used in developing a Risk Management Plan allows for a reasonably comprehensive review of the program risks and opportunities, and produces a set of tools to help alleviate the risk. It is prepared at the project outset, and should be reviewed and updated as the program matures. The tools include a set of risk indicators that help in early identification of risk and in the development of contingency plans.

Risk Management Plans are appropriate to projects that must be implemented by a certain date, as was the case with NAVIGATOR. The Olympic Games posed special operational needs to the regional ATMS partners. All operational planning assumed the full system would be in place for the games. A risk analysis and management plan was completed by GDOT in 1995, about 1 year before the games. There were few resources at that time that could be directed to developing the plan, and there was no guidance on risk analysis to direct the process. The plan was valuable in helping GDOT to set priorities and to allocate resources to the ATMS work most critical to Olympic

Games needs. It also identified contingency plans for some portions of the Olympics transportation management plan. As is true for any Risk Management Plan, some potential risks, such as the unavailability of certain ATMS components, were not considered.

One month before the games, when it became clear that the complete system would not be on line for the games, GDOT performed a "triage" review of the ATMS system functions. During that review, resources were allocated to bring key systems on line for the Olympic Games. Systems not considered critical were placed on hold until after the Olympic Games. This resulted in the implementation of key transportation management elements, and traffic management operations were modified to reflect the reduced ATMS capabilities. For example, the City of Atlanta could not address traffic signals remotely. The City of Atlanta pooled its own and GDOT traffic operations field personnel into Local Action Teams to perform necessary traffic signal timing modifications in the field as they were required.

As discussed earlier, transportation agencies are generally unfamiliar with control system projects. The processes and standards have not been developed to help manage these programs. GDOT followed FHWA guidelines and requirements in requesting a Concept Plan and Functional Specifications, two critical documents for defining and managing implementation of the regional ATMS, including the control system. In addition to the Concept Plan and Functional Specifications, other documents critical to program management (for which no FHWA or FTA guidance exists) include:

- **Systems Engineering Management Plan:** Describes the processes to be used to integrate the software and hardware in the control system, and to integrate communications and field devices.
- **Software Development Plan:** Describes the software development process including the structure of the software, a schedule of software function design, and progress/review/test milestones. Includes a method for tracking and documenting the software code.
- **System Test Plan:** A schedule of tests of the overall control system functions. Identifies test procedures and remediation plans if tests identify failures.
- **Configuration Management Plan:** A living document that describes the process for making system configuration changes and provides the appropriate forms for proposing and approving such changes. Encompasses system hardware and software.

These documents are described in more detail in Section 5. There was no formal guidance available regarding the development, use of, and importance of these or other system engineering documents such as the overall Program Management Plan, and Risk Management Plan. GDOT relied on verbal guidance from FHWA and on the expertise of the consultants.

MARTA's program management consultant was responsible for overall project management of the contractors who were designing and building the ITS MARTA '96 project, alleviating the need for MARTA staff to manage the detailed system procurement and installation. The ITS MARTA '96 program was much less complex than the Atlanta ATMS, and required only those program management tools that had already been developed at MARTA. MARTA typically uses consultants for program management support on similar systems projects such as the recently installed train control system and several extensions to the rail network. The consultant also provided quality control services by performing on-site field inspections of contractors as they installed components of the ITS system such as electrical lines, cabling, and conduit for the fiber optic cable. In this role, the consultant was able to resolve and correct potential problems in the field before installations were finalized.

4.4.6.2 Summary of Program Management

42. Program management of complex ITS programs requires tools not typically available at traditional transportation agencies. Processes and standards developed for traditional transportation works do not address the specific needs of ITS programs.

4.5 CONSTRUCTION

Traditional transportation infrastructure construction is guided by specific processes and procedures. Construction manuals have been developed that include forms to assist with project inspection and monitoring. Contract specifications have been created to control project execution and progress.

4.5.1 ITS Construction

When discussing ITS construction, the field devices must be separated from the control system. As described earlier, field device design and construction can be pursued as most traditional transportation work has been, with separate and distinct design and construction phases. However, it is almost impossible to distinguish the design from the construction phase for ITS control systems.

Processes and standards developed to guide traditional transportation system construction have been less successfully used for control system implementation, because traditional transportation projects do not involve software development or control system implementation. These specialized types of work require tools specific to them, and without them it is difficult to manage complex ITS programs. The tools used to manage ITS control system construction were described earlier in the section on Design (Systems Engineering Management Plan, Software Development Plan, Configuration Management Plan, etc.), and are, therefore, not addressed in this section.

This section focuses only on the issues related to managing ITS field device and TMC construction.

4.5.1.1 NAVIGATOR Experience With Field Device and TMC Construction

Typical construction contracts—PS&E documents—were prepared for the field devices and the TMC building. This section addresses the field device construction, and the effect of field device construction schedule delays on the control system implementation. Because of the pressure of the Olympic Games, plans were let for construction as soon as possible after they were complete. As noted in the timeline, two large sets of "lettings" were released—one in 1994 and one in 1995. This was not planned, and occurred simply because the work was completed and ready to bid. It was critical that work begin as soon as possible to meet the Olympics deadline. To ensure that the overall system was integrated, two contracts were developed and awarded. One was for field device integration (including communications systems), and a second was for control system integration. Despite these two contracts, it was very difficult to maintain coordination with the contractors. Although each contract included a clause requiring that information be provided to all other contractors, this clause was not very effective. The contractors viewed this requirement as a burden that would only slow down their own work, at the peril of incurring liquidated damages if they completed late. The Systems Integration meetings were very useful in ensuring information was exchanged, and the GDOT Construction staff provided additional liaison between contracts in the field.

Although most devices arrived in ample time to allow for in-office device integration and testing before field testing occurred, a few devices arrived very late. To meet the schedule, device integration occurred as the late devices were delivered. Therefore, the development "suite" was never completed and system integration and testing had to occur in the field. There was no time to create a complete development "suite" including the complete set of field devices. This introduced some problems in determining where problems were occurring within the system because the system software was never tested as a complete system off line. GDOT spent many hours with its consultants and contractors tracking down device failures and malfunctions.

A historical analysis of the trend of bid versus engineer's estimate revealed that costs steadily increased over time, with a marked increase noted in the second wave of contracts. In some cases, contracts that were bid at costs much higher than normally accepted were let because the Games were approaching and the contract was considered critical to managing Olympic Games traffic. The local contractors were glutted with work not only for GDOT and the ATMS partners, but also for the Olympic Games preparations. When contractors are busy, they tend to bid high, if at all, because they may have to pay overtime wages, and they are not that anxious to add to their current overburdened workload and risk liquidated damages if they complete late.

As the program leader, GDOT created a construction program implementation schedule. At first, projects were prioritized on the basis of how critical the work was to completing the regional ATMS. Projects were also prioritized on the basis of how critical they were to the management of traffic during the Olympic Games. As the project progressed, the prioritization was modified on the basis of a variety of reasons including progress of the plans, ability to procure necessary materials, schedule slippage, and personnel availability. Updates were maintained and tracked in the Traffic Engineering Office.

GDOT Construction staff coordinated extensively with the Traffic Engineering staff to ensure that any changes proposed during construction would not conflict with the overall regional ATMS concept. The Construction staff took on the responsibility for ensuring that all field device construction was coordinated including participating in a committee to develop the fiber allocation plan. The plans were reviewed by the Construction staff approximately 2 mo before they were let for bid, allowing them to incorporate any changes needed. The lead construction engineer noted that the plans required many supplements to ensure that adjacent plans were coordinated and that there were not "gaps" between plans. He became the central point of contact for ensuring that all construction resulted in an integrated whole.

Only one construction contractor default occurred during the construction of the field devices and supporting infrastructure for the regional ATMS. This was on the I-75 Ramp Metering project, which was not a critical element to Olympic Games transportation management. The contract specifications default clause was quickly activated, and the contractor's bond was paid within 2 wk.

GDOT retained the consultant selected for the overall ATMS program (including the building design) to serve as a construction manager for the TMC building construction. In commercial building construction, the architect/engineer often provide both design and construction management services. However, this type of role is unusual for traditional transportation agencies, as it is more similar to a design/build approach. The consultant construction manager began its work based on the assumption that its role would be as is typical for commercial building construction. This included the capability to approve field changes to the building design and approval of contract cost supplements. GDOT had not intended to provide this type of authority to the contractor. It wanted the consultant to act in an advisory role only. The role and responsibility of the consultant with respect to the building construction was resolved several weeks after the work commenced, by which time the consultant had provided the building contractor with direction and approved some changes that had not been approved by GDOT. The consultant felt that it could work more effectively and improve the construction schedule if it had the authority to approve changes. GDOT did not believe that it could assign the authority to obligate State funds to a consultant, and was also concerned that it would not be part of all of the decisions made in the

TMC building construction. Therefore, GDOT did not provide such authority to the contractor.

MARTA's program management consultant performed on-site field inspections of contractors as they installed components of the ITS system such as electrical lines, cabling, and conduit for the fiber optic cable. In this role, the consultant was able to resolve and correct potential problems in the field before installations were finalized.

4.5.1.2 Summary of Construction

43. Construction plans for field devices need to be well coordinated and planned to ensure that they result in a complete, integrated system. The plans must be checked to ensure they form a complete system, and this should be the responsibility of a single contact.
44. Field device construction can follow typical PS&E processes successfully.
45. The roles and responsibilities of outside consultants brought on as building construction managers must be clearly defined and understood—Are they acting as agents for the transportation agency with all the responsibility and decision-making authority of agency staff, or are they serving in an advisory role?

4.6 FINDINGS

The preceding sections provide 45 lessons learned (summary points) regarding ITS deployment. Many of the lessons learned relate to the differences between traditional transportation projects and ITS projects. This section combines the information presented in the summary points with results of focus group discussions conducted to develop fundamental findings that can help guide future deployments.

4.6.1 Fundamental Lessons Learned From Focus Group Results

Based on focus groups conducted in September and December 1996 with the NAVIGATOR member agencies, ARC, FTA, and FHWA, fundamental ITS program needs were identified. The needs are based on the difficulties these agencies encountered when they attempted to adapt traditional transportation practices to the needs of ITS. Two basic needs were identified:

- The need to develop procedures and measures of effectiveness for ITS programs
- The need to have the appropriate personnel and financial resources to apply the ITS processes and standards

The definition of these needs is described below. The ATMS partners recognized that, to successfully implement ITS, they need to adopt new "ways of doing business," and provide new types of support. For traditional transportation projects, there is extensive support provided by the agencies and FHWA and FTA. There are design manuals, procurement manuals, training courses, workshops, and publications that are continually updated. This type of support exists on a more limited scale for ITS.

The ATMS partners also recognized that their skills need to be enhanced to support ITS deployment. They need to learn how to approach systems engineering projects and how to manage them. The skills needed to operate and maintain ITS systems are different from those typically found in traditional transportation agencies. In addition, they believe that ITS system performance can be maximized when agencies work together. To improve interagency coordination, they believe that their own coordination skills should be improved. Recognizing that many agencies may not have the resources to be able to improve skills in all of these areas, they endorsed the option for agencies to use outside resources to meet the need. However, this option prompted some agency staff to comment that they would still need to improve their understanding of ITS processes and technologies to enable them to be effective managers of outside consultants.

4.6.1.1 ITS Procedures and Measures of Effectiveness

The following section defines the terms "procedures" and "measures of effectiveness."

- **ITS Procedures:** Guidance on how ITS programs should be conducted, i.e., what should be included in program management, what documents and deliverables are needed.
- **ITS Measures of Effectiveness:** Guidance on a basis for comparison or measurement to determine completeness and appropriateness of project deliverables, to measure progress, and to determine how well the system meets the requirements.

As described in many of the lessons learned and reiterated in the focus group discussions, transportation agencies are currently performing ITS projects without the benefit of guidance on how such projects should be conducted and how to determine if the outcomes meet the requirements. While traditional transportation projects are guided by multiple manuals and other guidelines, ITS projects are not. However, because ITS is still maturing, the ATMS partner agencies and FHWA and FTA strongly advised that overall *guidance*, not strict *guidelines* (full of requirements), be developed that can respond to the evolving nature of the work.

4.6.1.2 ITS Personnel Skill Areas

Three basic skill areas were identified via the focus group exercises that distinguish ITS projects from traditional road or transit works:

Interagency Coordination Skills: Skills related to revealing shared goals and assisting with decision consensus among a variety of interest groups, and maintaining open and unbiased communications.

Program/Project Management Skills: Skills related to overall program and project management, including programming the funding for large regional projects; managing projects with uncertain outcomes; managing projects involving multiple agencies; managing system implementation projects; and working with consultants that are truly "outside experts," bringing skills not available among existing staff.

ITS Technical Skills: An understanding of the detailed technical workings of ITS projects including software development, hardware design, system integration, communications technologies, and electronics.

Throughout the summary points, these skill area needs are found. To correlate the skill area needs and the need for guidance for ITS procedures and measures of effectiveness, the following table was developed. It lists each of the summary findings and indicates if the finding relates to the need for ITS skills or ITS guidance. The table forms the basis for synthesizing the summary points into the fundamental lessons learned.

Ref. No.	Summary Point	Skill Area: Program Management	Skill Area: Interagency Coordination	Skill Area: ITS Technical	Guidance: Recommended Approaches	Guidance: Measures of Effectiveness
1	ITS program operation and technology selection need to be investigated and outlined to develop robust early program scope and cost estimates. Doing so requires considerable up-front effort—more than is typical for traditional transportation projects at the same stage.			✓	✓	✓
2	There is not enough cost or benefit information available to assist agencies in matching ITS programs with needs, with gaining support, and to help the MPOs integrate ITS into the transportation planning process.		✓	✓	✓	✓
3	Incorporating the experience and knowledge gained from other ITS implementations improves early program definition. Scanning tours are one method to learn from other agencies, and can help in understanding ITS benefits.			✓	✓	
4	Begin early to promote and develop coordinated regional operations and ATMS capabilities. Develop the ITS concept in a collaborative forum.		✓		✓	
5	Continuous interagency coordination from planning through operations and maintenance is critical to the success of integrated regional ITS deployments.		✓		✓	
6	ITS programs require more interagency coordination than typical for traditional transportation programs.		✓		✓	
7	Some agencies are more committed than others to ITS. It is a challenge to bring on those that have little pre-existing commitment to ITS concepts.		✓			
8	Comprehensive operating agreements are essential in order to achieve the full benefits of an intermodal, interjurisdictional ATMS.		✓			
9	Law enforcement and other emergency services agencies will likely realize measurable benefits from participation in integrated incident management systems. Once they are able to actually see an ATMS in action, and how it benefits their own operations, they often become highly supportive of integrating with the regional ATMS operations.		✓			
10	There is a lack of guidance to support inter-agency coordination and decision-making for ITS programs. Different agencies often support different decision-making approaches.		✓		✓	
11	There is a lack of guidelines for the development of Concept Plans for ITS deployments. Since Concept Plans are the first step in overall ATMS deployment, they are critical to overall program success.	✓		✓	✓	✓
12	Field device implementations can generally be adapted to traditional PS&E processes. Modifications to the low-bid field device procurement process will better ensure proper field device performance and functionality.	✓		✓		✓
13	It is difficult to gauge progress in software development. In addition, there are many difficulties in translating a non-automated process to an automated one. The program management skills needed for ITS programs that include work outside of the traditional transportation staff's expertise, such as software development, are different from the skills needed to manage consultants performing work that the transportation staff is expert in. Therefore, custom-designed and developed software can represent the highest cost and schedule risk for an ITS program.	✓		✓	✓	✓

Ref. No.	Summary Point	Skill Area			Guidance	
		Program Management	Interagency Coordination	ITS Technical	Recommended Approaches	Measures of Effectiveness
14	Prototyping early and often is critical to software development success.	✓		✓	✓	✓
15	There are no standard guidelines in place at transportation agencies to help guide software development and mitigate risks.	✓		✓	✓	✓
16	Design and implementation of a complex control system incorporating multiple untried technologies is highly risk-prone in that there is not adequate prior experience to rely upon.	✓		✓	✓	
17	There are no processes in place at transportation agencies to guide configuration management of control systems.	✓		✓	✓	
18	The funding structure for ITS programs promotes adoption of the latest technologies because there are few funds available for future technology upgrades. This may result in late changes to the control system. If there are schedule pressures, late changes may affect the ability to complete the control system within the needed time frame.	✓		✓		✓
19	There is no guidance for the development of Systems Engineering Management Plans which, when well designed and followed, are critical to ensuring proper system integration.	✓		✓	✓	
20	To help manage and integrate multiple contracts, a Systems Integrator contract can be used. To facilitate coordination among multiple contracts, weekly meetings (with FHWA or FTA support as a facilitator) can be a highly effective tool.	✓	✓		✓	
21	ITS programs include components that present special regulatory and technical challenges that are not found in traditional transportation programs.			✓		✓
22	TMC building design and project management requires specialized expertise not typically found within traditional transportation agencies. Transportation agency construction standards differ from those in the building construction industry, and are difficult to adapt to building contract needs.	✓			✓	✓
23	Program management of complex ITS programs requires tools not typically available at traditional transportation agencies. Processes and standards developed for traditional transportation works do not address the specific needs of ITS programs.	✓			✓	✓
24	Many ITS components are difficult to incorporate into standard transportation-air quality models.			✓		✓
25	ITS programs should be incorporated into regional transportation plans.		✓		✓	✓
26	If transit ITS programs are not considered as part of the usual budget and funding cycle then special FTA grant agreements may be required that can introduce other funding conditions and funding schedule issues.	✓			✓	
27	The current Federal-aid (roads) funding processes and Federal-local (transit) funding relationship work for ITS.	✓	✓			
28	Coordinating the management of a multi-agency regional ATMS program can be simplified if a single agency is selected by the ATMS partners to manage the program.	✓	✓		✓	

Ref. No.	Summary Point	Skill Area: Program Management	Skill Area: Interagency Coordination	Skill Area: ITS Technical	Guidance: Recommended Approaches	Guidance: Measures of Effectiveness
29	Traditional local transportation agencies may have little ITS technical and program management skills and experience necessary for successful deployments. They may rely on outside support from peer organizations, outside experts, and the FTA and FHWA.	✓	✓	✓	✓	✓
30	The traditional Federal-local and transit program oversight and review relationship can be adapted to complex ITS deployment programs. Daily interaction can result in improved coordination and technical support, and reduced review time.	✓	✓			
31	Many road agencies do not bring on outside program management assistance, and may overlook the funding needs for such assistance.	✓			✓	
32	Many traditional transportation agencies experience difficulties in creating and funding new positions needed to manage an ITS program, and rely on existing staff or outside assistance.	✓			✓	
33	The proportion of life-cycle costs including cost to deploy devoted to operations and maintenance are higher for ITS than for traditional transportation projects. Thus, operations and maintenance funding is even more important to ITS than to traditional transportation projects.	✓			✓	
34	Even if adequate staff are available to support ITS operations and maintenance, they may require initial and on-going training in specialized ITS skills. This initial training could consume considerable resources and could take longer than expected.			✓		
35	Difficulties in recruiting, paying competitive salaries, and retaining staff have led agencies to use outside operations and maintenance service providers.	✓		✓	✓	
36	Agency staffing policies are often not flexible enough to allow agencies to readily create the specialized staff positions required for ITS operations and maintenance. The process often requires political and top management support.	✓				
37	A regionally integrated ATMS may benefit from regionally coordinated operations and maintenance. However, the long-range funding commitments necessary to create a coordinated funding pool are difficult to obtain.	✓	✓			
38	An earlier understanding of the staff needs for operations and maintenance may have helped agencies create and fund staff positions (if needed).	✓		✓	✓	
39	The complete scope of work for an ITS program, such as NAVIGATOR, cannot be defined until after the system concept and functional requirements are developed.	✓	✓	✓	✓	✓
40	Procurement processes developed for traditional transportation programs are not well suited to complex ITS programs, particularly the software and systems integration portion of the contracts.	✓			✓	
41	Transit agencies have procured systems in the past, and have developed procurement policies and guidelines appropriate to ITS systems needs. Due to this, the FTA procurement guidelines are more flexible when processing technology-based systems than these road agencies. Road agencies are less experienced with system procurements and often do not have appropriate contracting mechanisms.	✓			✓	

Ref. No.	Summary Point	Skill Area: Program Management	Skill Area: Interagency Coordination	Skill Area: ITS Technical	Guidance: Recommended Approaches	Guidance: Measures of Effectiveness
42	Using fixed-price contracts for ITS systems work may overly constrain the program because the scope is hard to clearly define up front, and the decisions made during the system design portion of the work may affect the overall cost.	✓			✓	
43	Construction plans for field devices need to be well coordinated and planned to ensure that they result in a complete, integrated system. The plans must be checked to ensure they form a complete system, and this should be the responsibility of a single contact.	✓			✓	
44	Field device construction can follow typical PS&E processes successfully.	✓			✓	
45	The roles and responsibilities of outside consultants brought on as building construction managers must be clearly defined and understood—Are they acting as agents for the transportation agency with all the responsibility and decision-making authority of agency staff, or are they serving in an advisory role?	✓			✓	

Despite the lack of pre-developed standards, GDOT and MARTA were able to implement a complex, regionally integrated ATMS in a highly compressed time frame. It has been estimated by FHWA staff that a similar program, if implemented without the schedule constraint in Atlanta, would have taken at least 10 years to accomplish. GDOT was able to achieve NAVIGATOR in 5 years, despite the fact that it was the first in the United States to implement such a system, and despite the difficulties of attempting to adapt standards developed for traditional transportation programs. Future ITS programs can benefit from GDOT's experience.

5.0 RECOMMENDATIONS

The following recommendations are suggested to improve implementation of ITS programs throughout the United States.

This section begins with a discussion of recommended ITS project steps including a set of suggested tasks important to ITS system deployment. Not only are the actual tasks themselves important, but it is also important to note at what point they are recommended to be accomplished. This set of tasks can be used as a template or guideline for agencies considering ITS projects. In addition to outlining the tasks, the special skills needed (compared with those typically found in traditional transportation agencies) are described for each major project phase.

Also included in this section is a set of recommendations for Federal and local agencies (State, regional, city, county, transit provider, etc.) to better support ITS deployments. The recommendations are specifically addressed to the ITS skill area needs and the need for standard ITS processes and guidelines.

5.1 THE STEPS TOWARD ITS DEPLOYMENT

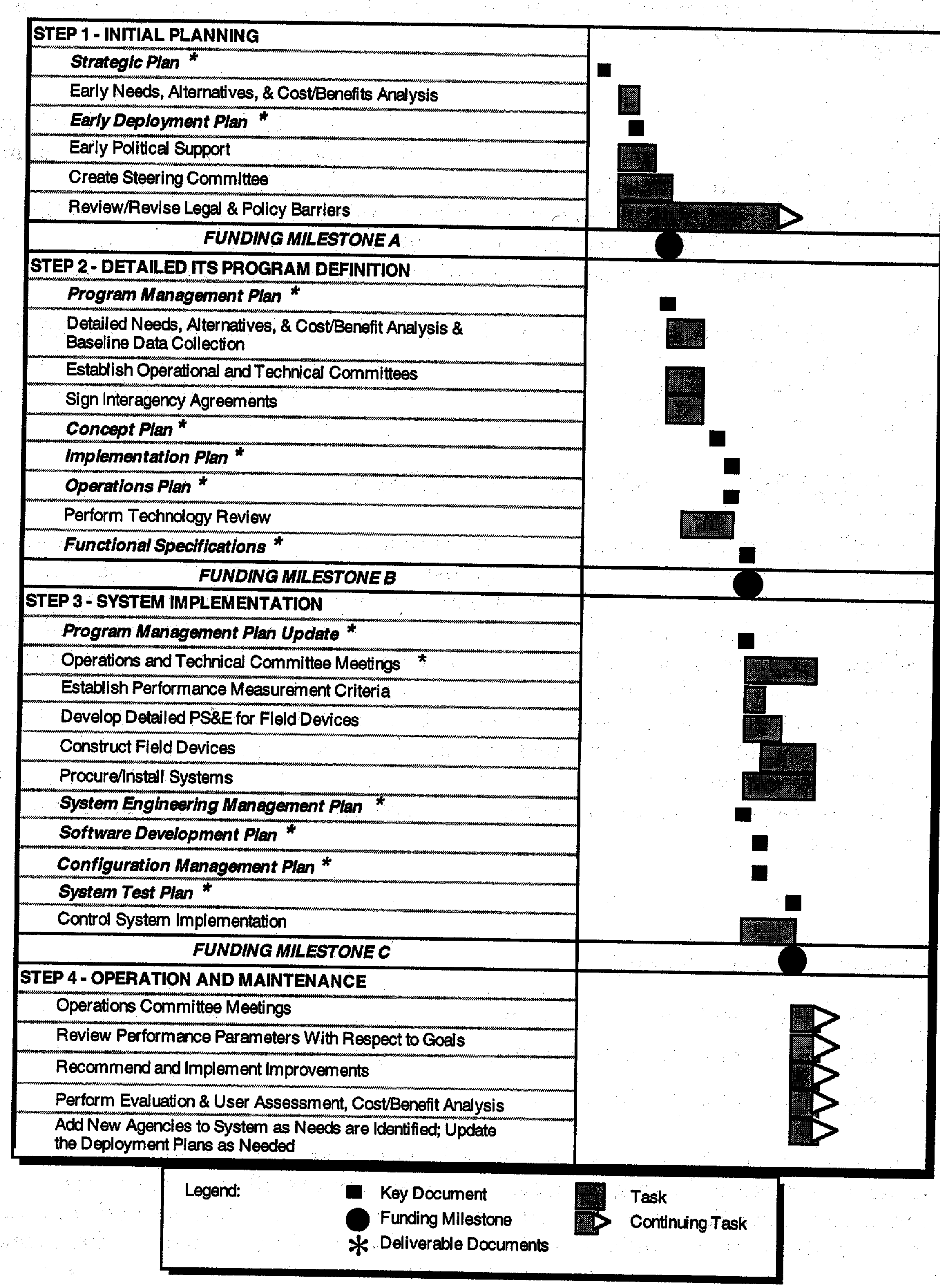
ITS deployments can be divided into steps that conclude with major decision milestones. The major steps can be distinguished from each other because each presents different technical and program management needs. The overall goal of the suggested strategies outlined herein is to support these needs, ensuring that the appropriate resources are available at all agency levels. It is also suggested that the basic organization of ITS projects—the major steps defined by the needs and resulting in decision milestones—be supported. One of the key lessons learned is that road transportation agencies must amend their view of projects to better support ITS. One step toward that change is to develop practices that fit ITS projects, rather than attempting to make ITS projects fit practices designed for traditional transportation works.

Four main steps are identified:

- Step 1—Initial Planning
- Step 2—Defining the ITS Program
- Step 3—System Implementation
- Step 4—Operate and Maintain

Figure 5-1 shows the major steps, the tasks within each major step, and the dependency structures linking the tasks. The steps are described in the pages provided following Figure 5-1. Within each of the main steps are several important tasks. Each step requires different skills based on the needs presented by these tasks.

FIGURE 5-1
The Steps Towards Regional ITS Development



Following steps 1 through 3, funding milestones are identified:

Funding Milestone A: Follows the Initial Planning step. At this point, there is enough preliminary information to develop preliminary scope and cost estimates for an ITS program—including staff needs.

Funding Milestone B: Follows the Define ITS Program step. At this point in the process, interagency operational agreements have been developed that affect the ITS program functionality. Because this discovery process often results in modifications to the details of the ITS program, a funding milestone is inserted at this point to ensure that the originally programmed funds will continue to be adequate.

Funding Milestone C: Follows the System Implementation step. This milestone is inserted to ensure that future operations and maintenance needs, if not already provided for, are funded.

Each of the steps indicates the level of needs for the three skill areas—Interagency Coordination, Program/Project Management, and ITS Technical Skills. The skill level need is described with respect to the baseline skills typically found at traditional road and transit agencies. The skill needs through the project steps are shown at the bottom of each page detailing a major project step. Following the summary sheets is a discussion of each of the steps, including NAVIGATOR experience to provide insight into each step's importance. It is recommended that "The Steps Toward Regional ITS Development" be used to guide ITS program conceptualization and implementation.

The following sections provide insight into the NAVIGATOR experiences during each step, and describe some of the issues that are most critical to the success of the ITS program.

5.1.1 Initial Planning Activity

The tasks identified in the Initial Planning Step focus on interagency coordination. Such coordination is required to complete the Early Deployment Plan, to develop early political support, and to create the Steering Committee. Early involvement of all those potentially involved is important to build shared visions and goals for regional ITS. As noted by Rodriguez and Sussman,[1] *"A truly strategic regional system architecture for ITS requires major political and institutional support."*

---

1 David Rodriguez and Joseph Sussman (1997), "Framework for Developing a Regional ITS System Architecture," presented at the 76th Annual Meeting of the Transportation Research Board, January 12-16, Washington, D.C., Pre-Print No.: 970893.

STEP 1: INITIAL PLANNING

Outcomes: ***ITS is integrated into regional multimodal transportation planning process. Application for funding is submitted.***

TASKS:

Perform early needs, alternatives, and cost/benefits analysis

- The early needs, alternatives, and benefits assessment should result in an Early Deployment Plan that is guided by the ITS Strategic Plan.
- The ITS alternatives and cost/benefit analysis should be integrated into the regional transportation planning process, allowing ITS to be evaluated against traditional transportation program needs.
- The Early Deployment Plan should include an analysis of the staff needs to manage, operate, and maintain the ITS.
- The analysis should provide adequate detail to develop robust ITS program cost estimates and scopes of work.

Obtain early political support

- Support should be sought from the management at the transportation agencies at the highest level, and from elected officials.
- Staff support for an ITS program should also be promoted and created.

Create Steering Committee of agency decision makers

- This process assumes that an ITS Strategic Plan has been developed.
- The Steering Committee is the forum for creating consensus on the basic ITS needs, functions, and operating concepts to be presented in the Early Deployment Plan.
- Include transportation decision makers from affected municipalities, police, fire, and other emergency response agencies, and MPO(s).
- Technical subcommittees should also be appointed to advise the Steering Committee. Their membership should include affected transportation and emergency response operations staff.

Review/revise legal and policy barriers

- Legal and policy barriers should be investigated in several areas including procurement processes, contracting, tow dispatch policies, privacy issues, and public-private partnership issues (if applicable). Other barriers specific to the local agencies may arise, and should be addressed as soon as possible.

FUNDING MILESTONE A:

- Develop scope and cost estimate to fund the ITS program—including staff needs.

KEY DOCUMENTS:

Strategic Plan (Prepared in advance of contemplating a regional ATMS)

- Describes how ITS programs can meet the vision, mission, goals, and objectives of transportation agencies.

Early Deployment Plan

- Identifies and prioritizes transportation needs and ITS programs to address them in a given region or corridor.

STEP 1 SKILL NEEDS:

Interagency Coordination	Program/Project Management	ITS Technical
LOW / MED / **HIGH**	**LOW** / MED / HIGH	**LOW** / MED / HIGH

STEP 2: DETAILED ITS PROGRAM DEFINITION

Outcomes:

- ***Adequate information is provided for affected agencies and others to understand system functions and field device locations.***
- ***Interagency agreements regarding operations and maintenance are signed.***
- ***Cost estimates are refined.***
- ***Baseline data is collected.***

TASKS:

Detailed needs, alternatives, benefits and cost evaluation, and baseline data collected

- Develop more detailed evaluation of ITS program and components.
- Establish expectations of system benefits and gather baseline data for future performance evaluation.
- Perform a risk assessment, and establish contingency plans if needed.
- Incorporate non-ITS traffic and incident management techniques into the program to maximize performance.
- Provide input to the Concept Plan.

Establish operations and technical committees

- The operations committee develops consensus on how the ATMS addresses on-street operations such as accident response plans, traffic diversion plans, and ramp meter/traffic signal coordination plans. This provides input to the Concept Plan and Operations Plan.
- The operations committee also establishes a coordinated maintenance plan for the regional system, including determining appropriate shares for funding maintenance activities.
- The technical committee establishes Functional Specifications and focuses on the review of hardware and software options to meet them.

Sign interagency operating and maintenance agreements

- Detailed operations and maintenance agreements are developed and executed between ITS member agencies.

Perform technology review

- Prepare an alternatives analysis and evaluation of field devices and control system components. This provides input to the Concept Plan and Functional Specifications.

FUNDING MILESTONE B:

- Ensure that the originally programmed funds will continue to be adequate.

KEY DOCUMENTS:

Program Management Plan

- Describes how overall program management will be conducted, including schedule and cost tracking and management; how decision-making is performed; the responsibilities of the various affected agencies and their consultants; and communications protocols.

Concept Plan

- Includes alternatives, cost/benefit, risk, and contingency analyses.
- Provides preliminary details of field devices, preliminary operational and functional concepts, and field device technology selections.

Operations Plan

- Includes details of how the control system will function to meet the operational needs of the ATMS, including interagency protocols and user interfaces.

Functional Specifications

- Defines each of the control system functions necessary to meet the operational scenarios established in the Concept Plan. Identifies standards that must be met for the control system implementation, and includes an evaluation of alternative methods of providing control system functions.

Implementation Plan

- Divides the ITS program into distinct contractual components, and provides an implementation schedule. Identifies lead agencies for specific program components, and establishes project coordination needs. Identifies actual and planned funding sources for projects.

STEP 2 SKILL NEEDS:

Skill			
Interagency Coordination	LOW	**MED**	HIGH
Program/Project Management	LOW	MED	**HIGH**
ITS Technical	LOW	MED	**HIGH**

STEP 3: SYSTEM IMPLEMENTATION

Outcomes: ***A functioning regional ATMS, meeting goals established in the previous steps, is deployed.***

<u>TASKS:</u>

Maintain operations and technical committees

- The operations and technical committees should be maintained, with the technical committee being most active at this time.

Establish performance measurement criteria

- Methods should be developed by the operations and technical committees to measure performance once the system is installed.

Develop detailed PS & E for field devices

- Develop bid documents for field devices including communications systems, cameras, vehicle detection devices, CMSs, etc.

Construct field devices

- Procure and install field devices per PS & Es.

Procure/install systems

- ITS systems, such as those for transit ITS including AVL, should be procured and installed at this time.

Control system implementation

- Based on the System Implementation Plan, the control system for the ATMS should be implemented.

<u>FUNDING MILESTONE C:</u>

- Ensure that future operations and maintenance needs are funded.

<u>KEY DOCUMENTS:</u>

Program Management Plan Update

- Update the Program Management Plan in light of the construction and implementation tasks that were identified in the previous program step. Include reference to the Software Development Plan and Configuration Management Plan.

Systems Engineering Management Plan

- Describes the methodology and milestones in systems integration, and control system development and testing.

Software Development Plan

- Describes the methodology and milestones in software development and testing.

Configuration Management Plan

- Provides protocol for and documentation of control system hardware and software changes.

System Test Plan

- Describes how proposed testing routines will ensure that the system functionality is as specified and to identify potential failures.

STEP 3 SKILL NEEDS:

Interagency Coordination	Program/Project Management	ITS Technical
LOW | MED | HIGH	LOW | MED | **HIGH**	LOW | MED | **HIGH**

STEP 4: OPERATION AND MAINTENANCE

Outcomes: ***Operation, maintenance, and continual improvement of the ITS is accomplished.***

<u>TASKS:</u>

Maintain operations committee

- Maintain operations committee to track ITS performance, maintain interagency relationships, evaluate proposals to modify system on-street operations, coordinate maintenance and training needs, and evaluate proposals to upgrade hardware, software, and field devices.

Review performance parameters with respect to goals

- Develop annual report of ITS performance with respect to performance goals.

Recommend and implement improvements

- Recommend improvements as suggested by the performance committee. Integrate ITS improvement needs into the regional transportation planning process.
- Perform continuous technology review to scan for potential upgrades to ITS.

Perform evaluation and user assessment

- Using the baseline data gathered in Task 2 - ITS Program Definition, perform an evaluation of system performance, including a cost/benefit analysis and a user (travelers and ITS partners) assessment of the system benefits.

Work to add new agencies to the system as needs are identified

- Identify appropriate additional regional ITS partners on the basis of current and projected transportation needs, and bring them into the program via interagency agreements.

<u>FUNDING MILESTONE:</u>

- Ensure that joint agency operations and maintenance contracts are signed and maintained to successfully obtain adequate funding for operations, maintenance, and system upgrades.

<u>KEY DOCUMENTS:</u>

- None identified for this report, although several documents including operating procedures, evaluation, and performance reports are necessary.

STEP 4 SKILL NEEDS:

Interagency Coordination	Program/Project Management	ITS Technical
LOW **MED** HIGH	**LOW** MED HIGH	LOW **MED** HIGH

The Steering Committee should determine which agency should lead the regional ITS program. An independent agency might be created especially for ITS, as was TRANSCOM in New Jersey. Rodriguez and Sussman[2] also found that *"Creation of a new regional agency or entity for managing ITS coordination and deployment (rather than an existing agency) enables an architecture definition with broader system functionality. ...existing agencies or entities constrain the ITS functionality because the architecture will be subject to the existing entity's goals and objectives."*

The Steering Committee should include regional transportation agencies (road and transit) and emergency responders. Emergency responders are often overlooked in ITS planning because transportation agencies have led ITS development. In addition, emergency agencies have not found many benefits from participating in ITS programs, which they view as primarily traffic management programs. In a recent study evaluating emergency responders' attitudes toward ITS programs in San Francisco,[3] it was found that *"...emergency agencies do not have a strong inclination to process real-time traffic information. Moreover, since emergency vehicles are authorized to preempt traffic signals and other vehicle movement, it seems that routing services (as could be developed using an ATMS) are not a priority item for them."*

However, emergency responders are key to developing highly successful incident management programs. In the same paper, it was found that, by simply agreeing on incident response protocols (not necessarily involving ITS), incident response could be greatly improved and relationship building could begin for future electronic incorporation of emergency agencies into an ATMS. In recognition of this, the San Antonio Model Deployment Initiative project will demonstrate integrating 911 dispatch with the ATMS.

Relationships with emergency responders in the Atlanta metropolitan area are gradually improving as successful projects are implemented. There was generally only mild interest in participating in the ARC-led incident management committee meetings. However, there was a positive police response to the installation of accident investigation areas on freeways. In addition, the coordinated operations during the Olympic Games and the GDOT HERO program improved police-transportation agency relations. The City of Atlanta Police Department set up a temporary Olympic Games traffic operations center that was connected to the regional ATMS. The experience was so positive that the Atlanta Police Department installed a permanent traffic operations center.

During the Initial Planning process, ITS projects should be reviewed on par with other transportation projects as part of the regional transportation planning process.

---

2 Ibid.

3 Hong Lo (1997), "Organizing for ITS: A Case Study of Emergency Operations for the San Francisco Bay Area," presented at the 76th Annual Meeting of the Transportation Research Board, January 12-16, Washington, D.C., Pre-Print No.: 970138.

Viewing ITS projects as alternatives to traditional transportation improvements will help bring ITS into the mainstream. If possible, conventional transportation projects must be considered as alternatives to ITS projects if they address the same needs and are at all feasible.

Without the support of agency leaders, resources cannot be applied toward planning, deploying, and operating ITS systems. To obtain that support, a clear description of the transportation needs, alternative actions and their costs (both monetary and non-monetary), and benefits of the alternatives must be presented. The staff needed to deploy, operate, and maintain the system should also be presented as early as possible in the process.

One of the critical tasks that should be performed during the Initial Planning Step is the review and revision (if needed) of potential legal and policy barriers to ITS. Most significantly, procurement and contract processes should be reviewed. Some major schedule delays occurred during NAVIGATOR because GDOT did not have procurement processes in place that are needed for ITS, including contracting instruments for consultant services and for procurement of needed development hardware. This is a barrier at most local agencies that are organized for building and operating traditional transportation projects rather than for ITS projects. Developing more appropriate procurement and contracting tools would likely require both legal and policy reviews and changes. These changes must occur early on in the process, before they become obstacles.

Other barriers include interagency agreements that may conflict with the preliminary operating concept. To improve incident management and response, agencies in the Atlanta region successfully revised policies regarding towing dispatch and accident clearance procedures.

Other potential legal and policy barriers can arise in ATMS/ATIS projects in addition to those encountered in Atlanta. For example, when projects include public/private partnerships, special issues related to the partnership may arise.

5.1.2 Detailed ITS Program Definition

It is at this stage that the regional planning to address transportation needs should be completed and specific ITS programs should be identified. The strategies outlined in the early needs assessment are fleshed out in this step. For example, an early needs assessment may have identified a need to install ramp metering on a particular freeway segment. This strategy is expanded to include traffic analysis to identify the ramp meter locations and the possible queuing impacts; to identify whether HOV queue-jumps should be installed and where; to quantify the delay and safety benefits; to identify the operating scheme (when they would operate); and develop a footprint plan for field device installation. From a systems standpoint, the concepts of operating ramp meters as a stand-alone system versus integrating them into a freeway incident management system or with adjacent traffic signals are evaluated. The hardware, software, and communications needs of each functional scenario are developed and compared.

The ability to use non-electronic methods for traffic flow monitoring and incident detection and integrating them into a traffic or incident management concept should not be overlooked in the detailed alternatives analysis. For example, telephone communications protocols may be more desirable than computerized communications links for some traffic or incident management applications.

The ITS program evaluation should be based on the expectations regarding the system benefits established in the Concept Plan. This is critical to evaluating system performance once deployment is complete. It is difficult to measure how well a system is performing if the design expectations are not identified up front. Once the Concept Plan and performance expectations are established, the baseline data can be collected for use in a future evaluation. Baseline data cannot be collected until this time, because the data needs cannot be identified before the performance parameters and expectations are defined.

Interagency coordination continues to be key during this step. Two committees should be established at this time: operations and technical. The operations committee concentrates on what happens on the street, including concepts such as accident response procedures, traffic signal, and ramp meter coordination. The technical committee is charged with reviewing the hardware and software needed to accomplish the on-street operations. At this step, the operations committee will be more active than the technical committee. Many agencies will not possess adequate skills and/or resources to serve on the technical committee. Often, the same staff person will serve on both committees. The provision of the necessary technical resources is key to the success of an ITS deployment.

The agency operations staffs need to be brought together to discuss how the ATMS system should function. Strong political barriers exist to interagency coordinated traffic management. However, the existence of a regional ATMS capability can improve interagency coordination and help remove political barriers. Therefore, the agencies should describe their desired operations plan *and* the currently achievable operations plan based on institutional barriers.

Some agencies will not commit to working together toward regional traffic management from the beginning for a variety of reasons. These are typically political, resource, or education based. Some agencies are just trying to keep potholes filled—investment in ITS is far beyond their vision. Education can be an even larger barrier than resources. In the USDOT report "IVHS Institutional Issues and Case Studies,"[4] it was found that a *"...problem that has caused poor lines of communication within state and local government partner organizations is the fact*

[4] USDOT, FHWA (1994), "IVHS Institutional Issues and Case Studies," Washington, D.C., DOT-VNTSC-FHWA-94-15.

that their respective surface transportation organization and personnel have not yet caught up with the technology explosion that the IVHS program represents." However, agencies with needs that can only be addressed via ITS will catch up in the future, particularly if the system shows some early and dramatic benefits. Therefore, these agencies should be considered as shadow partners, with the overall system plan including them at a conceptual level.

Because regionally coordinated ATMSs cannot be achieved without interagency cooperation, it is critical that operating and maintenance agreements include how the system will be operated and who will bear the costs to operate and maintain the system.

ITS programs are often very complex, including several individual projects. The predesign and concept planning should include a System Implementation Plan including a list of contracts, what each contract includes and the estimated cost, the funding source, and a schedule of construction. This early program planning is critical to maintaining the construction schedule and provides information to the regional ATMS system partners regarding when they should expect their systems to be brought on line and when they need to allow time to monitor construction. Also, with the projects and funding sources identified, a final program review can be performed, ensuring that all of the necessary conditions for each funding type are met and reducing the chances of delays to construction.

5.1.3 System Implementation

Interagency coordination is critical to successful ITS implementation. The operations and technical committees should be maintained, with the technical committee being most active at this time. As stated earlier, many agencies do not have the technical resources required to support ITS design and construction. Provision of the necessary technical support is key to successful ITS deployment.

To ensure that the ITS system provides the benefits that are expected and to facilitate continual operating improvements in the system, methods should be developed by the operations and technical committees to measure performance once the system is installed. As much as possible, these methods should be automated and included in the system design.

This stage includes the detailed design and construction of all ITS program components. All field devices, all systems, and the control systems will be implemented. Design, procurement, and installation of ITS field devices and systems have generally been successfully accomplished using existing processes found at traditional DOTs. However, the control system implementation is so different from traditional transportation work that several new standards are required to develop and manage the control system implementation. The minimum required documents are briefly described in Section 5.2, and include a Software Development Plan, a System Test Plan, and a Configuration Management Plan.

5.1.4 Operate and Maintain

Operations and maintenance are not explicitly part of this Case Study, which focuses on the deployment of NAVIGATOR. However, the issues related to operations and maintenance of ITS are touched on during the deployment process, and are significant enough that they warrant mention in this report.

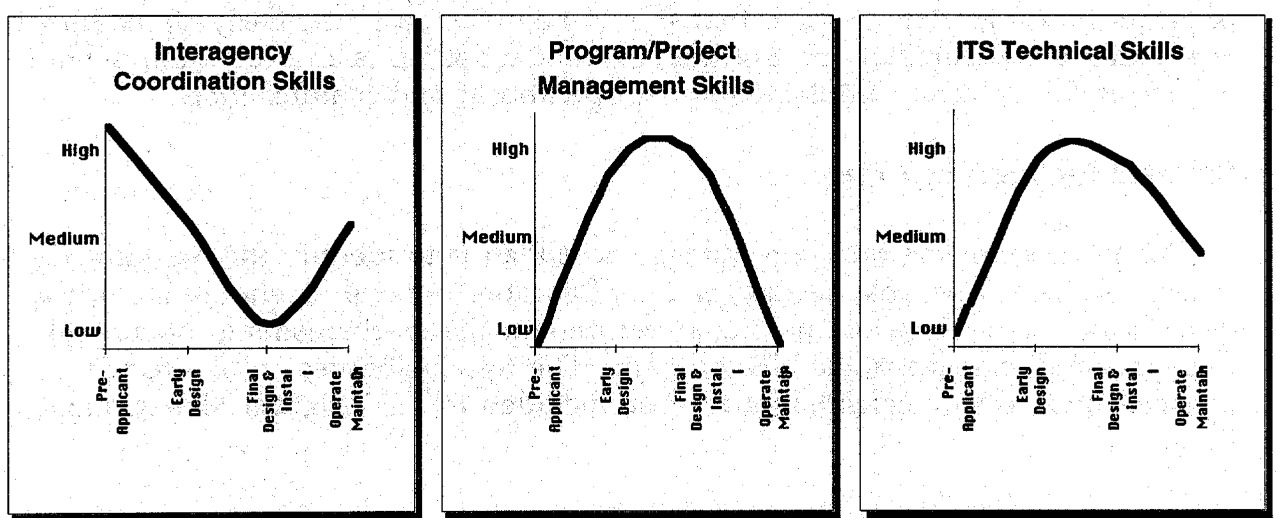
During the operations and maintenance phase, the operations committee reconvenes to support ATMS functions. Typical operations committee goals include performance measurement, maintenance of interagency relationships, evaluation of proposals to modify system on-street operations, coordination of maintenance and training needs, and evaluation of proposals to upgrade hardware, software, and field devices. Committee members must possess not only traditional traffic engineering skills, but also ITS technical skills. The operations committee should develop consistent standards and evaluation criteria for reporting ITS system performance. This report should be the basis for requests for system upgrades that are beyond the capabilities of the local staff. Improvements recommended on the basis of the performance reports and the discussions of the operations committee should be implemented.

As discussed earlier, some agencies that were candidates for participation in the regional ATMS system may not have elected to join at the outset. Contact with these agencies, and others that emerge as potential participants, should be maintained. Information to assist these agencies in deciding to participate can be developed by the operations committee.

5.1.5 Summary of Skill Area Needs

As shown in Figure 5-2, the needs for each of the three skill areas varies throughout the project steps. Hence, the need to support these skill areas also varies. Interagency coordination skills needs begin at a high level; taper off to a lower level at project pre-design, system implementation, and construction; and remain there throughout operation and maintenance. ITS technical skill needs are lowest during initial planning, but are high thereafter. Program/project management skill needs are also lowest at the initial planning phase, highest through the design and construction phases, and return to low during operations and maintenance.

FIGURE 5-2
Skills Needed for ITS Programs



5.2 DESCRIPTION OF RECOMMENDED DOCUMENTS

The following is a series of documents that are recommended for use to support an ITS program. Brief descriptions of each of these documents are provided. The documents are the fundamental tools that encourage technical discipline and fiscal accountability in the ITS program and control system development and implementation process. Many of these documents are already required under current Federal programs. The recommendation to include these documents in ITS programs reinforces those pre-existing requirements. In addition, the description clarifies the purpose and content of each document.

ITS Strategic Plan

The purpose of an ITS Strategic Plan is to identify the vision, mission, and goals and objectives of the transportation agencies responsible for transportation resources and services within a given geographic are (often state wide), and to present a strategy for deployment of intelligent transportation systems through which to achieve those goals and objectives. Critical issues in the planning, design, deployment, and operations and maintenance phases, including funding, institutional issues, and technologies are typically examined in the strategy. A coherent architecture and an organized, complementary set of projects are presented. The ITS Strategic Plan was not specifically addressed in this Case Study, because it is assumed to be complete before a regional ITS program such as NAVIGATOR is pursued.

ITS Early Deployment Study

The purpose of a ITS Early Deployment Study is to examine and prioritize the transportation needs of a region, sub-area, or corridor and to develop a plan for resolution of those needs through ITS projects, in compliance with the ITS Strategic Plan. This is the first product that provides more specific information regarding a regional ITS program, and is used to develop preliminary cost estimates for ITS program funding. One element that should be included in the Early Deployment Study that is not currently part of the Federal Guidelines is an evaluation of staff needs for ITS program implementation, operations, and maintenance.

Program Management Plan

The purpose of the Program Management Plan is to identify the mechanisms to be used for schedule, cost, design, and configuration control. It should include a description of the decision-making structure and the mechanisms to document decisions and changes in the ITS program. The responsibilities of all affected agencies and outside consultants are also included in the Program Management Plan.

Concept Plan

The Concept Plan consists of two sections: the Requirements Analysis and the System Concept. The purpose of the Concept Plan is to identify the ITS operational and functional concepts.

Requirements Analysis—The Requirements Analysis begins with an inventory of what types of transportation surveillance and management operations are currently in place. It establishes the requirements or goals of the ITS program. The requirements should be supported by previously conducted studies or mandated requirements (i.e., air quality, mandated safety, etc.) It should also include an analysis of alternative ITS approaches, cost/benefit analyses, and risk assessment of each alternative approach. The focus of the Requirements Analysis is not on ITS systems or functions, but operational capabilities and the resulting transportation-related benefits that are desired.

The following are examples of higher-level statements from a transportation management system requirements analysis:

- The surveillance component will have the capability to provide real-time, video surveillance on all segments of all major interstate and State highway expressways within, and on the express beltway. This requirement will include color video, and be able to provide electronic speed/volume data on all segments of the expressways.
- The Traffic Operations Center will have complete access to all remotely located cameras and surveillance systems within the county, and will have access, by voice request, to designated and compatible surveillance systems in the State.

- The roving incident patrol vehicles should be tracked by location (when desired by the operator or decision maker) on an electronic map in the Traffic Operations Center, and will have dual communications capabilities with law enforcement and the Traffic Operations Center.

- The AVL system will be able to track the location of all buses and, along with the use of route adherence software, will identify which buses are on schedule, behind schedule, or ahead of schedule.

System Concept—The System Concept relies on the Requirements Analysis as a baseline, attaching ITS field devices, systems, and control system capabilities directly to the operational requirements. It will also include some basic system physical configuration layout model or architecture (i.e., central management center, remote centers, etc.). The System Concept gives some shape to the technical capabilities that are identified in the Requirements Analysis, including surveillance, communication, and the approach to system control. A technology review of the most current field devices should be included in the System Concept.

The Concept Plan is an extremely important tool in the procurement of ITS programs. It establishes a refined scope of work and cost estimate for the complete ITS program. Because of the refined information provided in the Concept Plan, it is suggested that a program funding review be completed after Concept Plan approval, to determine if previously programmed funds are adequate for the complete ITS program. If additional funding beyond that originally programmed is required, the cost/benefit analysis can be used to prioritize ITS program components.

Operations Plan

The Operations Plan is directly related to the Concept Plan. It describes how the ATMS partner agencies will interact with the ATMS, with the field devices, and each other. The Operations Plan should provide step-by-step descriptions of ATMS-related practices such as incident response or ramp metering operations.

Functional Specifications

The Functional Specifications describe the functions expected of the control system on the basis of the operations and field devices selected in the Concept Plan. They define each of the control system functions that must occur to support the operational concept. The Functional Specification should also include standards and specifications that must be met in the control system design (e.g., IEEE, NEMA, etc.). Examples of functional descriptions for a traffic management system might include:

- Speeds along expressway segments that are measured to be (on average) more than 15 percent below normal conditions for that time of day will automatically be flagged to the Traffic Operations Center. This automatic flag can be over ridden when congestion is due to known construction or special events.

- Incident symbols will flash on the main display screen until the control system has acknowledged a response from the shift supervisor function.
- Bus icons will be displayed on the AVL map with route number and an arrow indicating travel direction.
- All incidents will be classified using numeric descriptors of incident severity, which will correspond to the number of lane closures, including incidents that do not involve lane closures.

Functional Specifications are critical for system software development and system integration, which are usually the most complex tasks in an ITS control system implementation. The Functional Specifications also directly affect the layout of the control center(s) which, in turn, influences the design and cost of the building and physical plant housing the system control.

Functional Specifications should describe control system hardware (including quantity and type), specific controlling types of systems, and communications capacity requirements. Examples of high-level Functional Specifications statements for a traffic or transit management system might include:

- Video cameras shall contain full-motion (360 degrees vertical, 40 degrees up, 40 degrees down) pan/tilt/zoom capability.
- Passenger Information Devices shall be capable of operating in outdoor environments, with messages visible in full sunlight and nighttime ambient lighting from a distance of 50 feet.
- All traffic signals to be served by the network shall be capable of adaptive and interconnected traffic signal control.

More detailed (less high-level) specifications are created on the basis of high-level specifications and are used to design the user consoles and interface at the control centers, and the internal control system hardware and software. These include specifications related to, for example, the performance of the communications system.

Functional Specifications are necessary in making final and accurate estimates of equipment costs for contracting processes. Specifications also assist in the refinement of the scheduling of building construction and control system equipment installation, since it will usually be known how long it will take for certain types of equipment to be furnished, based on known order dates.

System Implementation Plan

The System Implementation Plan is meant to structure and schedule ITS Program implementation. It describes the proposed field device and communications system construction contracts, and integrates the field device construction with the control system implementation needs. It is a useful tool to identify where construction projects are planned to meet and interface, and should describe how the contract interfaces will be managed. In addition, the System Implementation Plan should include a review of other transportation system construction contracts in the area, and should identify opportunities for incorporating ITS construction into them, or describe how potential construction conflicts will be managed. The control system implementation schedule is also included in the System Implementation Plan, as it must be coordinated with the field device, communications system, and (if required) TMC building projects.

Systems Engineering Management Plan

The Systems Engineering Management Plan guides development of the control system and overall systems integration. It should describe how the hardware for the control system will be selected and integrated with the system software, and identify major milestones in systems development and integration. It should also identify what systems will be integrated, when, and who is responsible for integration and testing. Both pre-existing and new systems should be described. The Systems Engineering Management Plan includes ties to the Software Development Plan, the System Test Plan, and the Configuration Management Plan.

Software Development Plan

The Software Development Plan describes the methodology and milestones in software development and testing. Software development is a top-down process that entails the following basic steps:

- Design analysis
- Module development and coding
- Module (sub-routine) integration testing
- Total software system testing

Details of how each of these steps will be performed should be included in the Software Development Plan. Software module development and coding are generally much easier to accomplish when the requirements and design processes have been thoroughly thought through and reviewed. This also allows more realistic estimates of the number of lines of code required, which is one of the basic estimators for system throughput requirements.

A prototyping plan and schedule should also be included in the Software Development Plan to tie software development with the user operations and interface. The prototyping plan should ensure that prototyping is done early and often, and that alternatives are developed and presented.

System Test Plan

Testing adds value to the development of the system in two important ways:

1. To ensure that system functions meet operational requirements
2. To determine if system functions, as tested, meet document descriptions.

The System Test Plan outlines the testing needs and schedule for the control system. Much of system testing occurs during the software development process, particularly in module development and basic module compatibility assessment. The System Test Plan should include scenarios that force the demonstration of all of the major integration items.

Configuration Management Plan

Configuration Management (CM) refers to the management of system hardware, software, and other system control relationships and changes over time. CM establishes clear roles and responsibilities, how changes to systems are introduced, and their disposition.

CM is normally performed during system development by the developing contractor up until the approval of the system critical design. Then, the CM function normally transitions to a Configuration Control Manager (CCM), who is supported by a Configuration Control Board (CCB), which is populated by the various technical representatives involved. Using proper CM, no changes in the system configuration baseline (software, hardware, or other controlling/integration systems) can occur without CCB approval.

CM processes are supported by documents, including a CM Plan (updated over time) and a roster of CM change proposals and actual changes. Thorough CM is instrumental in reducing dependence on the development contractor for both operations and maintenance of the system during the later stages in the life cycle. The CM Plan describes how control system and field device hardware and software decisions are made, and how changes to the configuration are agreed to and documented.

Systems Integration Report. The Systems Integration Report is an output of the CM Plan, and documents the complete control system software and hardware, including the changes and modifications made in the process of control system implementation. It is an on-going process that begins at the functional requirements stage, and becomes increasingly important during software development and system specifications stage. The resulting document is a detailed report on the technical interfaces and protocols between:

- System control software and other (administrative) software components
- System communications and control systems
- System software and hardware components

The systems integration report is the fundamental baseline for system integration testing. This report is also extremely important for operations and maintenance, because when components are being replaced by new technology systems potential integration issues need to be examined before a purchase decision is made.

5.3 RECOMMENDATIONS

The recommendations presented below are intended to support the special needs of ITS deployment on a local or regional basis. Each agency can determine if its existing programs and policies comply with the strategies outlined. It can also determine the best ways to modify its programs and policies to better align with ITS needs. Each agency's approach may differ somewhat from the recommendations presented below, based on their unique experiences and circumstances.

The "Steps Toward ITS Deployment," including the deliverable documents and ITS Skill Needs, are the basic recommendations of this report. It is recommended that they be used to guide future ITS programs. More specific recommendations to support these tools and the need for skills development and the creation of processes and standards to meet the needs of ITS programs are provided in the following tables. The tables provide recommendations for both Federal and local agencies. The recommendations are grouped into three areas based on the goals they address. The goals are related directly to the findings based on the Atlanta experience.

Successful projects generally are focused on deliverables or products and the steps and tasks necessary to produce them. The following recommendations are intended to help strengthen the focus on the essential "deliverables" of ITS projects and the ways to "produce" them.

TABLE 5-1
Develop Guidance for ITS Procedures
Federal and Local Level Recommendations for ITS Guidance Support

Goal of the Recommendations	Federal Level Recommendations	Local Level Recommendations
FINDINGS: Develop Guidance for ITS Procedures		
ITS Process Support	Develop guidance documents for the execution of ITS programs (the Steps to ITS). Encourage modifications to Federal assistance role for ITS programs to be more interactive, providing support and involvement on a day-to-day basis. Support the development of interagency operations and technical committees by providing guidance for committee goals and decision-making processes. Assist local agencies in establishing appropriate roles for consultant assistance—Are outside consultants working as independent experts, providing advice to the local agency, or are they acting as local agency "agents," supplementing staff? Provide performance measurement guidelines to assist local agencies with the development of ITS program performance measurement standards. FHWA should evaluate the system procurement process used by FTA, and, if appropriate, adapt it for use in procuring ITS systems. Provide support to local agencies to assist in the development of procurement processes that meet ITS needs in the form of case studies of other local agencies, guidance on selection of procurement processes (professional services, non-professional services, goods), and technical assistance to assess local agency procurement barriers. Provide support to local agencies to assist in the development of contracting mechanisms that meet ITS needs in the form of case studies of other local agencies, and technical assistance to assess local agency contracting barriers. Facilitate better incorporation of ITS programs into regional transportation plans by providing information regarding ITS costs and benefits, ITS transportation impact analysis tools, and air quality impacts of ITS to local agencies.	Institute ITS process guidelines including major review milestones. Create and maintain on-going ITS coordinating committees. Consider enlisting support from the local MPO to assist in committee activity coordination. Develop and institute ITS program performance measurement processes to monitor performance after ITS program deployment. Local agencies should review and resolve barriers to developing contract mechanisms that are well suited to the needs of ITS programs. Bring ITS program plans into the regional transportation planning process as early as possible.

To understand how well an ITS program is progressing and how well it is achieving its intended objectives, there must be a basis for comparison. Implementation of the recommendations that follow will provide the documentation necessary to effectively plan ITS progress as well as track progress and measure the final "deliverables" against the program goals and objectives.

TABLE 5-2
Develop ITS Measures of Effectiveness
Federal and Local Level Recommendations for ITS Guidance Support

Goal of the Recommendations	Federal Level Recommendations	Local Level Recommendations
FINDINGS: Develop ITS Measures of Effectiveness		
Develop Standard Documents to Guide ITS Programs	Provide guidance to local agencies for the development of the following documents: • ITS Strategic Plan • ITS Early Deployment Plan • Program Management Plan • Concept Plan • Operations Plan • Functional Specifications • System Implementation Plan • Systems Engineering Management Plan • Software Development Plan • System Test Plan • Configuration Management Plan	Either follow Federal guidance if documents are prepared in-house, or clearly define requirements in contracts if outside assistance is used, for the following documents: • ITS Strategic Plan • ITS Early Deployment Plan • Program Management Plan • Concept Plan • Operations Plan • Functional Specifications • System Implementation Plan • Systems Engineering Management Plan • Software Development Plan • System Test Plan • Configuration Management Plan If no Federal guidance is available, use other ITS deployments elsewhere as examples.

Three of the five major findings of the study involve the need to enhance ITS technical skills. Without attending to these skills, an ITS deployment is likely to be difficult and may even fail. The following sets outs specific recommendations to address skill needs.

TABLE 5-3
Improve/Program Project Management Skills, Interagency Coordination Skills, ITS Technical Skills
Federal and Local Level Recommendations for ITS Guidance Support

Goal of the Recommendations	Federal Level Recommendations	Local Level Recommendations
Improve Program/Project Management Skills, Interagency Coordination Skills, ITS Technical Skills		
ITS Skill Area Support	Promote capacity building for Federal and Local staff in the areas of interagency coordination, program management, and ITS technical skills. Assist local agencies in the assessment of skill area strengths and needs. Provide access to national public and private sector leaders in ITS technology. Support local agency efforts to supplement staff needs internally. Support local agency efforts to supplement staff needs externally.	Provide capacity building for ITS staff in the areas of interagency coordination, program management, and ITS technical skills. Consider teaming with local MPOs or other regional forum to enhance interagency coordination. Assess agency skill area strengths and needs at the early ITS program definition stage—including staff needs for operations and maintenance. Develop external support network of national ITS public and private sector technology leaders. Begin early to identify and resolve barriers to the creation of appropriate internal ITS staff positions. Begin early to identify and resolve barriers to using outside support contractors to provide appropriate ITS skills.

Recycled
Recyclable

HSR-10/11-98(1M.191)E